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THE LANGUAGE OF PATENT DOCUMENTATION

JAZYK PATENTOVÉ DOKUMENTACE

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RECOMMENDED LITERATURE:

Krhutová Milena: Parameters of Professional Discourse, Tribun EU, 2009

Seville, C. (2016) EU Intellectual Property Law and Policy. Edward Elgar Publishing

Urbanová, L. (2008) Stylistika anglického jazyka. Brno: Společnost pro odbornou literaturu - Barrister & Principal.

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GUBERNÁT, Tomáš. Jazyk patentové dokumentace [online]. Brno, 2021 [cit. 2021-05-31]. Dostupné z: https://www.vutbr.cz/studenti/zav-prace/detail/134529. Bakalářská práce. Vysoké učení technické v Brně, Fakulta elektrotechniky a komunikačních technologií, Ústav jazyků. Vedoucí práce Milan Smutný.

Abstract

The subject of intellectual property can be very complicated. This bachelor's thesis focuses mainly on intellectual property from a scientific and industrial standpoint and the discourse of patent documentation. This thesis aims to provide an overview and a quick guide for any potential applicants for patents or any other types of intellectual property described in this thesis - be they from the public or scholarly. This thesis is further focused on the analysis of the language of the patent documentation, which is very nuanced, and caveats encountered during the creation of patent application, during the grant procedure, or even after the patent was granted.

Abstrakt

Odvětví duševního vlastnictví se může na první pohled zdát velmi komplikované. Tato bakalářská práce je zaměřená zejména na problematiku duševního vlastnictví z pohledu výzkumu a průmyslu, ale také i na jazykový diskurz patentové dokumentace. Má sloužit jako souhrn důležitých informací a orientační návod zejména pro potenciální uchazeče o patenty či jiné druhy duševního vlastnictví, ať už z řad veřejnosti či akademického světa. Nedílnou součástí této práce je analýza nuancovaného jazyka patentové dokumentace, a náhled na možná úskalí při tvorbě žádosti o patent, během procesu získávání patentu nebo i jeho ztrátu.

Keywords

EPO, WIPO, IPO, patent law, patents, trademarks, industrial designs, utility models, geographical denominations, intellectual property, patent documentation, patent claims, language analysis

Klíčová slova

EPO, WIPO, ÚPV, patentový zákon, patenty, ochranné známky, průmyslové vzory, užitné vzory, geografické ochranné známky, duševní vlastnictví, patentová dokumentace, patentové nároky, jazyková analýza

Rozšířený abstrakt

Tato práce se věnuje duševnímu vlastnictví, což je problematika, která je velmi komplikovaná, a zároveň velmi důležitá. Zajišťuje totiž, že tvůrci mohou profitovat ze své činnosti, což může pozitivně působit na vznik další tvůrčí činnosti, jelikož tvůrci nebudou mít obavy, že jejich práce bude ukradená nebo jinak zneužitá.

V první části této práce jsou popsány druhy duševního vlastnictví v rámci vědy a průmyslu, tedy ochranné známky, průmyslové vzory, užitné vzory a geografická označení. U těchto druhů je uvedeno, jaké aspekty vynálezu či výrobku ochraňují a jak se dají získat v rámci nejen České republiky. Dále je popsán samotný koncept patentů, spolu s detailním popisem procesu jejich získání – ať už na národní, Evropské či mezinárodní úrovni – a k práci je přiložen tiskopis žádosti o patent. Také jsou představeny mezinárodní úmluvy a konvence které tuto problematiku ovlivňují.

Jelikož jsou patenty i další druhy duševního vlastnictví velmi závislé na již známých objevech, je zkoumána i možnost podání odporu, ať už proti rozhodnutí úřadu či proti přihlášce samotné. Relevantní poplatky a procesy jsou také popsány spolu s předvedením konkrétního příkladu procesu, který v současné době stále probíhá.

Jelikož je toto odvětví velmi komplikované a je snadné se v něm ztratit, je zkoumán i koncept patentových zástupců a poradců – v rámci Asociace Patentových Zástupců i Evropského patentového úřadu.

Epidemie onemocnění COVID-19 otřásla základy celého světa, a proto se poslední podkapitola první části věnuje právě této problematice. I když samotný přihlašovací proces nebyl nijak ovlivněn (protože už předtím probíhal bezkontaktně), jsou předneseny dva případy, ve kterých byla platnost patentu omezena pro získání více zdravotnického materiálu – v prvním byl patent dočasně zrušen, v druhém (plicní ventilátor CoroVent) dočasně zpřístupněn všem.

Na úplném konci první části této práce jsou uvedeny způsoby, kterými se může žadatel o patent připravit o samotnou patentovatelnost svého vynálezu, a to zejména jeho zpřístupněním třetí osobě dříve, než o patent vůbec zažádá, například médiím. Tato kapitola také krátce zmiňuje obvyklý postup v případech, kdy je vynález výsledkem zaměstnaneckého výkonu.

V druhé části této práce jsou analyzované dvě patentové přihlášky. V jednom se jedná o zařízení pro detekci dotyku, v druhém o jednu z metod boje s koronaviry. Tyto rozdílné příklady byly vybrány mimo jiné i pro ilustraci intertextuality, zejména v ohledu uspořádání dokumentu. Bylo totiž zjištěno, že i když byly předloženy patentovým kancelářím v jiné části světa a téměř 20 let od sebe, je jejich struktura velmi podobná. Více intertextuality se odehrává v pozadí těchto dokumentů, jelikož součástí procesu udělování patentů je průzkum, který má za účel nalezení veškerých souvisejících dokumentů, které souvisí.

Dále bylo zjištěno, že obsahují velké množství výrazů a obratů typické pro vědecký a právní diskurz, a naopak neobsahují jakýkoliv figurativní jazyk, který by mohl přinést nežádoucí dvojsmysly. V této analýze jsou prozkoumány zejména části, ve kterých přihlašující přednese nároky, které chce, aby byly chráněny. Jsou to totiž tyto části, podle kterých se odvíjí samotný výsledek celého procesu, a případné protesty či rovnou soudní procesy, ve kterých může záviset na každém slovu. Bylo zjištěno, že na jazyk těchto nároků jsou kladeny vysoké požadavky, co se týče jednoznačnosti – mimo jiné i absolutní dodržování pravidla, které říká, že musí být napsány v jedné větě. Toto vede k velmi dlouhým souvětím, které jsou až strojeně prodlužovány zejména diakritikou. Vysoké nároky na jednoznačnost jsou dále ilustrovány i porovnáním používání výrazů „comprising of“ /„consisting of“ a „amount“ / „plurality“.

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1. Introduction

Intellectual property (IP) laws are complicated but of the utmost importance. They ensure that the proprietor of the IP can enjoy the benefits of his work, which in turn creates a healthy environment in which new ideas can be created without fear of being stolen and/or used in a way that the proprietor may not agree with.

In the first part of this thesis, the concepts of intellectual property will be described with an emphasis on patents and a description of their governing bodies operating in Czechia. An overview of the process of obtaining such a patent within the said governing body will be provided, as well as a brief description of how a patent can become invalid or upfront unobtainable. Different kinds of intellectual property protection will be introduced and discussed similarly to patents.

As for the second part of this thesis, the language of a document concerning a patent in the field of electrical engineering will be analysed on to different examples. The language used within those documents should be a mix of technical and legal English, which would be consistent with the contents of the document. Based on this, the language should also lack ambiguity, to prevent any possible misunderstandings.

2. Intellectual property and patents

1.1 What is Intellectual Property?

According to the World Intellectual Property Organization (WIPO), “intellectual property refers to creations of the mind, such as inventions; literary and artistic works; designs; and symbols, names, and images used in commerce” [1]. As stated in the introduction to this thesis, protection of such property is not only integral for the creators in the process of gaining benefits from their work – either recognition or financial gains – but also for bolstering further advancements in various fields by securing a clear motivation for future artists, scientists, businesses, and inventors [2].

1.1.1 What is a patent?

The (WIPO) describes a patent as „*an exclusive right granted for an invention which is a product or a process that provides, in general, a new way of doing something or offers a new technical solution to a problem*“ [3].

Patents are used to protect an invention or inventive technology from anyone seeking to derive economical gains from it without the consent of the owner. However, „*a patent does not confer a right to make use of or exploit an invention. It is a right to prevent others from deriving economic gain from the technology without the owner’s permission*“. [4].

In Europe, patents are governed by the European Patent Office (EPO), which is the executive part of the European Patent Organisation [5]. It was created as a result of a treaty signed in 1973 by sixteen countries, the European Patent Convention. At the date of submission of this thesis, EPO now operates in 38 countries: the European Union, Albania, Iceland, Liechtenstein, Monaco, North Macedonia, Norway, San Marino, Serbia, Switzerland, Turkey, and the United Kingdom [6].

This treaty established the office, detailing the inner structure of the office, mode of operation (public service), source of finance for the operation of the office (member countries), and, most importantly, guidelines for obtaining a patent from the EPO [7], which will be discussed further in this thesis.

As of the date of submission of this thesis, the current president of the EPO is António Campinos, who was inducted for his lifelong contribution to IP rights to the IP Hall of Fame in 2017 [8].

1.2 Protecting Intellectual Property

There are three types of protection of any IP that are guaranteed and require no registration: know-how, copyright, and unregistered design rights, with many more types requiring a registration. These will be discussed in the following parts of this thesis [9].

Know-how (or procedural knowledge) concerns implicit information that is essential for the function of a certain industrial process or an invention [10].

Copyright protects against the unauthorised use of documents, drawings, and photographs concerning an invention or any original idea in general [11]. These are also an essential part of the application for a patent, as described later in this thesis.

Unregistered design rights protect the invention’s outside appearance and design, and in some countries also protecting the inside appearance. It should be noted that not all designs can be protected, for example, if the invention uses an industry-standard design. It is possible to register a design, allowing the owner of the registration to challenge any similarly looking ideas [11].

This chapter will also provide a summary of practical information concerning the process of obtaining a patent in the Czech Republic (which are up to date as of May 2021) together with an overview of other types of intellectual property that either somehow interacts with a patent or are different kinds of protection similar to patents. For example, the pointer detection apparatus, whose documentation is discussed at a later stage of this thesis, is meant to be a part of a certain device. This device will most likely have a trademark to indicate the manufacturer or retailer and may have a unique design, further distinguishing itself from its competitors. It may also contain a unique solution to an issue with something already patented, which is protected by a utility model.

In the Czech Republic, the responsible office is the Industrial Property Office (IPO) established in 1919 This governmental office protects multiple areas of industrial property in terms of intellectual property, such as geographical denominations, industrial designs, trademarks, and utility models. As with patents, being granted protection for any of these types of intellectual property by the IPO translates into having protection in contracting states of the Paris Convention [12].

1.2.1 Trademarks

Trademarks are a unique identifier, usually easily recognizable and rememberable, by which products or services distinguish themselves from other similar products or services. These may include words, colour, drawing, letters, sounds, numbers, and the shape or packaging of a product. The application for this type of IP must include the trademark itself, the identity of the applicant, and the goods and services the trademark will be used for. The processing fee depends on who is applying for the trademark. Individuals or co-owners apply for an individual trademark, for which the processing fee is CZK 5000. Legal persons or associations apply for a collective trademark, and the processing fee is CZK 10000. Upon being granted, the individual trademark expires after 10 years, unless renewed for a fee of CZK 2500 before the date of expiry, or for CZK 5000 within 6 months of its expiration [13]. The fees for collective trademarks are doubled. The maximal period of protection for trademarks is 20 years [14].

Be it an individual or collective trademark, the application fee covers only 3 classes of products or services, and an additional fee (CZK 500) must be paid for any additional class [15]. This is different from the EUIPO, as each application in that office (€850 for online application, €1000 for paper form) covers only one class, but similarly, fees can be paid to increase this amount (€50 for the second class, €150 per the third and any subsequent classes) [16].

These classes are defined by the Nice Classification, established by the Nice Agreement in 1957 by WIPO, and applies to all states within the aforementioned Paris Convention - as well as being updated by a committee formed by experts from said states [17]. It is a list of 34 groups of goods and 11 services. The definition of each class consists of not only a list of specific goods or services that belong to said class but also of a definition of goods or services that are in a different class - although their nature may imply that they should belong in that class. For example, Class 32 includes non-alcoholic beverages, beers, mineral waters, fruit juices, and non-alcoholic substances for the production of beverages, but not flavourings based on essential oils, beverages for medical purposes, milk or milk substitutes, juices for cooking, plant-based beverages (coffee, cocoa – these are included in Class 30, which also covers, for example, non-raw cereals, pizza or pies) [18]. As for services, the definition is similar – Class 41 is about providing any kinds of education, entertainment, or presentation of art or literature for cultural or educational purposes [19], but excludes health spas (Class 44), news agencies (Class 38), or technical writing (Class 42, which is about services concerning theoretical and practical aspects provided by qualified professionals such as scientists or engineers, but e.g. legal (Class 45) or medical services (Class 44) are excluded) [20].

1.2.2 Industrial design

Industrial design protection concerns the outer appearance of a product, specifically the shape, colours, contours, lines, materials used, and structure [21] It also covers any decorations. Of course, there are also requirements, similar to those for a patent. The design must be unique and new (for a design to be new, the same design cannot be available to the public before the date of filing or the priority date (similarly to patents). The evaluation of uniqueness is based on the impression given to a potential customer; it must be different from any design available to the public before the date of application or the priority date.

The European Union Intellectual Property Office (EUIPO) manages international registrations of both trademarks and industrial designs. Aside from that, this office also provides guidelines for offices within individual countries about how to proceed and what are the requirements for such applications. For industrial designs, it must consist of a filled official form and an appendix to this form, containing accurate depictions of the design from all angles. Aside from a representation of the design, it should also contain disclaimers, which highlight the parts of a product that are not to be protected, and if it was granted, for which it does not apply [22]. As for processing fees, the IPO charges CZK 500 if the applicant is also the inventor, or CZK 1000 otherwise. The protection is valid for 5 years, after which the applicant can file for an extension for an increasing fee – from CZK 3000 to CZK 12000. Such extension can be made four times, totalling the maximum time of protection at 25 years. [13]

1.2.3 Utility models

Technological solutions to already existing patents are usually protected by a utility model, which is essentially a weaker form of patents. This form does not have to uphold an as high degree of creativeness (e.g., not being just a change of materials) and novelty as patents do, although the law states that some degree of novelty must be achieved, along with the solution having to go beyond professional skills and being industrially exploitable [23]. As can be expected, this type of protection does not extend to inventions that are usually protected by patents, since the aforementioned law excludes the following from the definition of utility models: scientific discoveries, modifications in the appearance of a product, production methods, computer programs, plants, animals or biological reproductive substances and immoral or illegal technological solutions [24].

According to the WIPO, utility models are subjected to different regulations in different countries, with some (e.g., USA or UK) not practising them, therefore they are not centralized [25]. In some countries, they are also called „short term patents“ (Belgium) or „Utility Certificates“ (France) [26].

The process of granting protection for this type of IP is also different from patents, as it is simply a matter of being registered. No searches are conducted (apart from a short evaluation according to the aforementioned criteria); therefore, the time window is much shorter (estimate 3 months). The application itself must include an official form, documentation, or description of the solution (sufficient to such degree that a professional can recreate the invention in question) and claims (similarly to patents). Furthermore, some countries allow patents, whose application was refused, to be registered as utility models, and allow an invention to be registered both as a patent and utility model [27].

Fees for utility models are lower than for patents. The application fee is CZK 1000 if the applicant is not the originator of the utility model, or CZK 500 if the applicant is the said originator. The renewal fee is CZK 6000 and can be paid twice after the original term of 4 years ends [13]. This extends the registration by 3 years, totalling the maximal term of the protection at 10 years [28].

1.2.4 Geographical denominations

This type of IP protection concerns the geographical names that are used to distinguish certain products that originate from a certain geographical location, but only if the unique properties of said products are obtained by certain characteristics of said locations - be it natural or human resources. The product may also be exclusively produced in or obtain its reputation from said area. In other words, the product must be closely connected to its place of production. Usually, this indicates traditional local products that are known for their qualities, functionality, taste, or other characteristics. The WIPO explicitly states that the techniques used in the production of these products are not subjected to this type of protection [29]. Appellations of origin are a subtype of geographical indication which are more closely connected with a certain geographical location, being exclusively produced there from locally sourced materials [30].

Applicants that apply for this type of IP protection can choose between national, European, or international. Either way, they must fill out a form with information about the full name of the geographical indication and the company or companies producing the product in question. The applicant must also provide a clear definition of the geographical area in question, describe the products, and provide evidence of the qualities that depend on this area. For geographical indication, this can be in the form of historical documents, certificates of quality, or scientific articles. For appellations of origins, the applicant must describe and prove how the natural or human factors unique to an area influence the unique characteristics of a product. The application fee for both types is CZK 4000 for national protection or CZK 2500 for international protection [31][32].

1.2.5 Obtaining a European patent

The process of obtaining patents from the EPO has multiple stages. First, the applicant must fill out a grant request, provide a detailed description of the invention, present his claims (defining the subject of the possible patent protection), provide drawings and an abstract [33], while also paying a fee which amounts to, as of the date of submission of this thesis, €1610 (€135 cheaper for an online application). However, further stages - up until the patent is granted - increase this amount to a total of €6100 on average. Some countries may also require additional fees in order to validate the European patent, and a recurring fee must be paid in each of those countries to maintain said patent [34].

At the filing of the application, EPO examines formalities such as identification of the applicant or whether all necessary documents are provided. After the application is accepted, the applicant has up to 2 months to claim the date of a previously filed application – if such application was filed within the last 12 months. This is because of Article 87 of the European Patent Convention, which enables „*any person who has duly filed, in or for any State party to the Paris Convention for the Protection of Industrial Property or any Member of the World Trade Organization* “[35] to later file application for the same invention in such country while claiming the filing date of the first application as the priority date of the second application to obtain priority. This priority date is then considered as the effective date of filing of the application and is used during further stages of the grant process [36].

After the patent is filed, formalities examination is carried out, checking the application's formal aspects. These include not only the form, content, and translations, but also whether fees are paid, or a professional representative is appointed [37]. During this examination, a European search report is created. This report provides an overview of other documents both known to the EPO at the time of the creation of this report and relevant to the assessment of the novelty of the patent [38]. This document is then communicated to the applicant, together with a preliminary opinion on whether the patent can be granted [39].

After 18 months from the date of filing or the earliest priority date, or upon request of the applicant, the application and the search report are published electronically at https://data.epo.org/publication-server [40].

If the applicant files a request for examination within six months after the aforementioned publication and the corresponding fee is paid, the examination stage of the grant process can begin, during which an examining division determines if the patent meets the requirements set by European Patent Convention – in other words, whether the patent is inventive or not (with regards to the search report and any comments made by the applicant [41][42]. As mentioned earlier in this thesis, European patents must be validated in order to be effective in certain individual countries [43]. There is also nine months (after the grant is publicized) period in place for filing an opposition to the patent [44]. Both the decision of the examining division and the opposition can be appealed to [45].

1.2.6 Obtaining a national or international patent

Before, during, and after the innovative process, the patentee should always research the state of the art, usually using the international patent database called Espacenet, available at https://worldwide.espacenet.com/ [46]. This is to either gain inspiration for innovation or prevent any possible IP infringements or other issues that may arise during the grant procedure. This preliminary search can also be performed by the IPO for a fee of CZK 5000 [47]. Then, the patentee should decide whether the invention is a patent or a utility model, according to descriptions provided in other parts of this thesis. However, in both cases, a decision must be made about how many and what other countries should the invention be protected in. Accordingly, the patentee will either file a national application, a European application, or an international application. It should be noted that there is a significant delay between submitting a national application and being able to register a patent internationally [48].

If the patentee wishes to apply for an international patent, a transmittal fee of CZK 1500 must be paid to the IPO, together with an application fee of €1233. However, this fee can be reduced by using an online form, and further reduced by 90% if the applicant is a natural person and a Czech national [49]. The search for this type of patent is conducted by the EPO (as it is the International Search Authority for Europe) and incurs a fee of €1775 [50]. This initiates the international stage, in which a search report together with a patentability opinion is written, and the application is published in the WIPO database, available at https://patentscope.wipo.int/. Afterward, in the national phase, the patentee will apply for patents in patent offices in different countries based on the patentee's decision. Although this incurs another application fee, the national offices will decide with regards to the decision of the WIPO [51].

The application fees for a national application in the IPO is CZK 1200, or CZK 600 if the applicant is also the inventor [47]. Furthermore, the applicant must request for a full search to be performed within 36 months after submitting the application. This search will confirm the state of the art and patentability and is performed for a fee of CZK 3000. By default, this search can only cover up to ten claims and every subsequent claim confers a fee of CZK 500. Similarly, to international or European patents, application for all the aforementioned types of IP protection is regularly publicized in a weekly bulletin of the IPO, available at https://isdv.upv.cz/webapp/resdb.vestnik.seznam?lan=cs. The renewal fee increases annually, ranging from CZK 1000 for the first year to CZK 24000 for the 20th year of validity [47]. The average success rate of all patent applications within the IPO is around 45% [52], and if the patent application succeeds, the patentee must also pay a fee of CZK 1600 for the certificate itself [53][47].

Supplementary patent certificates can be used if the patent in question concerns human and veterinary drugs or other biological agents. This certificate extends the maximum duration of protection by 5 years (totalling 25 years). It can be necessary because such substances are subjected to many medical or other trials and certifications, and the patentee cannot commercially use such substances until these trials are completed [54]. The application fee is CZK 5000 [55]. For an example of an application form, refer to Appendix 1.

1.2.7 Representation and legal advice in the field of IP

Due to the high degree of bureaucracy and expertise involved in this procedure, it is common for patentees to seek the advice or help of professionals such as advocates or professional representatives. These can help at any stage of this procedure, from creating the necessary patent documentation to representing the patentee in dealings with the patent office. Having an official representative is not obligatory for both natural and legal persons with their residence or place of business within the jurisdiction of said office. These representatives must be certified by the EPO themselves after passing an extensive exam and showing that they have a certain level of scientific or technical knowledge (university degree or 10 years of experience) or operate under an association of representatives (usually law firms) registered in the EPO [56]. The Czech Chamber of Patent Attorneys (all Czech patent attorneys must be members of this organization, similar to the Czech Bar Association) only requires 3 years of experience in the field of intellectual property, but its members cannot represent patentees applying for European patents unless these representatives are registered by the EPO as well [57][58][59].

1.2.8 Appeals

All first-instance decisions of the IPO can be appealed within one month after their validity for a fee of CZK 1000 (together with a deposit of CZK 2500 if the appeal concerns a patent, utility model, or a supplementary protection certificate) although this happens rarely [60] After an appeal is filed, an explanation must be provided within one month [61].

A well-known instance of a patent appeal is the case of the medication called „Sofosbuvir", patented by Gilead Sciences in May 2014 in EPO, which was a revolutionary cure for type C hepatitis as it improved the success rate and drastically reduced the duration of previously available treatments. Several non-profit medical organisations (including Médecins Sans Frontières) tried to challenge the patent for this drug, partly because they were concerned about the pricing of this drug, which wildly varied by different countries - a 12-week treatment for one patient cost €28000 in France and €48000 in the Czech Republic, which severely limits the availability of this treatment. In third-world countries, MSF is supplied by generic drug manufacturers, with the total cost per one treatment is €75 [62] The appeal was on the grounds of the drug being non-inventive and was rejected. However, appeal proceedings concerning this patent are ongoing. Oral proceedings were originally set to take place in July 2020, but they were postponed due to travel restrictions created by the COVID-19 pandemic to July 2021, and the patentee had recently filed a request for another postponement [63].

1.2.9 Influence of the COVID-19 pandemic

The COVID-19 pandemic has not influenced the applications in the field of industrial IP rights much, as all applications were already submittable online. However, as mentioned earlier in this thesis, oral hearings concerning appeals may have been postponed due to travel restrictions. On the other hand, already existing patents were affected by the need for medical supplies, which made way for compulsory licenses (in this case, without paying fees to the patentee). Such license, issued by individual governments, essentially revokes the patentee's exclusive rights and enables their competitors to produce the patented products. One of the first countries to establish such a license was Israel, in the case of a drug (originally used to treat HIV infection) that was found to help patients with the coronavirus. In reaction to this, the patentee suspended their exclusive rights worldwide, therefore establishing a public license [64][65]. Another well-known example of such action is the case of the mechanical ventilation device called CoroVent by the Czech Technical University in Prague. The patentee established a public license immediately after applying for a patent, enabling everyone to exploit all the rights usually conveyed by the patent for the duration of this license [64][65].

1.3 Losing a patent or patentability

European patents last for 20 years after the actual date of filing of the application [66] (not the priority date), but this period can end earlier – if the patentee revokes their patent, because of opposition or if renewal fees are not paid for [67].

However, a patentee might lose their rights for obtaining a patent. For example, if there are two or more applicants for a singular patent, only the application with the earliest filing date (or priority date) can enter the process for a grant [68]. On top of that, said priority date will be invalidated if the patentee does not provide sufficient formal documents, such as proper translations [69]. Although, rights lost in this manner can be re-established [70]

Another way of losing a patent is early disclosure. This may occur if the inventor discloses the nature of their invention via talking to individuals, media, or even student projects, where an original idea may be publicly exhibited [71]. For example, a company prepares a competition for students in which they are tasked to come up with a solution for an issue the company might face [72]. Should a participant come up with an innovative solution, they would most likely fail at obtaining a patent for it, since it was disclosed before the earliest date of filing an application or the priority date of such application. In other words, early disclosure can lead to the invention losing its status as a novelty, which is, as described earlier in this thesis, the main parameter observed during the patent process [73].

Early disclosure can be avoided by using a non-disclosure agreement, which is a written contract between two parties that concerns a piece of specific and unique information obtained from one of the parties involved, so the scope of this agreement can be very limited, and the second party may refuse to sign it, possibly terminating any previous agreement [74]

There are also cases in which the patent is a result of a performance of an employee's duty, which can result in the employer having full rights to the novelty. However, this may vary depending on the local law, and some form of recognition is usually in place, such as remuneration [75]. Common practise at some universities and research institutes is that the inventor gains scientific recognition via publishing their research, while the institution in which the inventor is employed gains the rights to the result of such research [76].

3. Language analysis of patent documentation

3.1 Context

The first example of selected patent documentation (provided as an appendix to this thesis) regards a patent application filed for at the EPO at 30.03.2010, but with a priority date of 18.06.2009. The inventors are Yasuo Oda and Yoshihisa Sugiyama from the company Wacom Co. Ltd, which is a company that specializes in pen displays, tablets, styli, and other forms of digitalization for the purpose of artistic creation [77]. In the application, they are represented by a patent attorney.

The invention in question is a pointer detection apparatus that is designed for touch panels and similar devices. The proposed electronic circuit essentially detects a contact of a pen or a finger using various frequencies selectively supplied to a mesh of conductors and then calculates the position of the pen or finger.

Completed search report can be found on page 95, and in this report, multiple relevant documents are listed - two of them having high importance. On page 97, it was found that the claims of the applicants are not compliant with the requirements of unity of invention, because they relate to existing inventions or groups of inventions. However, this means only that the patent application consists of multiple inventions, and a fee is required for the search report to cover other inventions than those that are covered in the partial search report. The patent application can still proceed to further stages of the grant process.

The second example is a US patent application filed in 1992 by a pharmaceutical company called Pfizer Inc., mostly known for their COVID-19 vaccine [78][79]. It concerns the composition and methods for vaccination against coronaviruses. This application was used in 1993 to claim the priority date for a European patent application. However, other documents (mostly communication between the office and the applicant) related to this application including a publication of an international patent application have shown that the claims were found to lack novelty. Subsequently, both parties tried to reach a mutual agreement on how to formulate these claims, which eventually did not happen due to the expiration of a period within which the applicant had to reply to the patent office – which caused the application to be deemed withdrawn [78][80].

This patent application was chosen because it illustrates the internationality of patents and the timelessness of the language of patent documentation. Furthermore, it shows that a major part of the research concerning modern COVID-19 vaccines was already done before the pandemic, and therefore was not hastily conducted, as some sources of disinformation claim [81].

3.2.1 Analysis of the documentation

It is apparent from both examples that the reader must possess relevant knowledge, be it in the field of electrical engineering and mathematics or biology and coupled together with the advanced vocabulary found usually within the discourse of technical English, this confirms the target audience to be other scientists, as suggested by other parts of this thesis [82].

As figurative language can be used to convey a different meaning than the written words usually mean, it is strictly avoided, as this may cause future problems (discussed in another part of this thesis) [83].

Patent applications are their own genre of technical writing; a combination of technical descriptions and administrative forms [84].

Both examples are written in the academic scientific prose style, as they are densely packed with detailed descriptions of the novelty in question. Furthermore, the overall composition leaves no room for ambiguity, although some degree of repetitiveness is present in both texts (mainly because of the claims section) [85].

As for register, both examples indicate that the tenor is impersonal, distant, and public, with the mode being non-interactive. The field of both texts is technical and legal, and they are written in the third person, they are planned and written-like [86].

With regards to the explanation of language functions provided by Brown and Yule (1993), the function for both examples is purely transactional. Similarly, if approached according to Jakobson’s (1960) explanation, the primary function is referential. However, the document may have an unintended conative function, as it aims to convince the patent office to grant the patent. This is not reflected in the text in any part of both documents. [87][88].

3.2.2 Analysis of the claims section

On page 45 of the first example, and page 44 of the second example, the applicants list their patent claims. This section is generally meant to clearly describe what exactly is the novelty the applicants intend to obtain the protection of, essentially setting boundaries of the patent. It is also extremely important for future inventors, as these claims define what exactly is protected by the patent and what is not. The claims use the same terminology and vocabulary as the previous specifications, although they are considerably more condensed as they must be as brief as possible – they are limited to one sentence only, which is usually achieved through heavy punctuation [89]. It should be noted that, unlike in previous parts of the document, no outside information (such as figures or other sections of the document) is referenced. Instead, claims reference each other using their numbers.

„*1. A pointer detection apparatus, comprising:*

a conductor pattern including a plurality of first conductors disposed in a first direction and a plurality of second conductors disposed in a second direction which crosses the first direction; (...) and

a signal detection circuit configured to detect signals of individual frequencies, corresponding to the signals of different frequencies produced by said multi-frequency signal production circuit, which are representative of coupling states at cross points between the first conductors and the second conductors, and are received from said second conductor selection circuit." (EP2264578A1)

This first claim from the first example describes what parts the apparatus consists of [3]. The rule of one sentence only is observed by the frequent use of semicolons resulting in a large compound sentence, which is comprised of clauses describing individual parts of the product. The individual clauses, written in passive voice (used throughout the whole document, and indicating that such document is formal) precisely describe the individual parts present within the apparatus and their configuration [90]. This is consistent with the first claim of the second example:

"1. A chimeric coronavirus S protein or fragment thereof comprising a first S protein fragment from a first selected coronavirus strain and a second S protein fragment, from a second selected coronavirus strain, said protein capable of eliciting an immune response in a host animal to a selected coronavirus" (US07/882,171)

The last sentence of the first claim of the first example is linked to the rest by using "and" after a semicolon at the end, but it is apparent from the second example that this is only because of the complexity of the first example. Also, further clauses reference each other using "said" as an adjective, which appears in many instances in the rest of the first example – confirming that the language of the document is a mix of technical and legal English, since the use of "said" as an adverb is a common practice in such documents.[91].

"2. The pointer detection apparatus according to claim 1, wherein said first conductor selection circuit is further configured to divide the plurality of first conductors into a plurality of groups each including M conductors, M being an integer equal to or greater than 2, to supply a signal of each of the different frequencies produced by said multi-frequency signal production circuit to one of the M conductors included in each group." (EP2264578A1)

In the second and subsequent claims of both examples, the adverb "wherein" is often used to reference previous claims while preceding clauses provide information about additional functions of previously described parts. This is required to achieve a clear and precise description of the novelty of the invention without the possibility of obscurity, as mentioned earlier in this thesis. This precision is further reinforced by constantly repeating the main function of such novelty at the beginning of each claim. It should also be noted that the claims section contains no hedging.

The requirement to describe every novelty in one individual claim is fulfilled to the highest degree, which can be seen in claims 7 and 8 of the first example, where the latter is the exact copy of the former, with the only difference being in the value of degrees:

"7. The pointer detection apparatus according to claim 1, wherein said phase controlling circuit is further configured to apply a phase dispersion pattern to the initial phases of the plurality of signals of different frequencies at <u>every ±45 degrees</u>.

8. The pointer detection apparatus according to claim 1, wherein said phase controlling circuit is further configured to apply a phase dispersion pattern to the initial phases of the plurality of signals of different frequencies at every <u>±22.5 degrees</u>." (EP2264578A1)

Although claim 1 of the first example had specified the parts of the apparatus in question, claim 15 adds an additional part. Based on a detailed description earlier in the patent documentation, this is because the part is nonessential for the function of prior parts (so that it would be nonsensical to refer to this part when describing prior parts) while the prior parts are essential for the function of this part:

„15. The pointer detection apparatus according to claim 1, further comprising:

a position calculation circuit configured to calculate a position of a pointer on said conductor pattern based on the signals of individual frequencies detected by said signal detection circuit." (EP2264578A1)

Throughout the patent claims, the first invention is referred to as a *"pointer detection apparatus"*. This is also due to the requirement to describe the use of the device precisely yet shortly, and it is consistent with the second example – "*a chimeric coronavirus S protein*"

According to WIPO, a proper patent claim must consist of the preamble, transitional phrase, and the body [92]. The preamble is "the designation of the subject-matter invention" [93] or, in other words, a category of the invention in question [92]. In this case, the device is used to electronically detect a finger or other objects touching a specific area, therefore the shortest plausible description is "pointer detection apparatus". Transitional phrases are divided into open-ended and closed [94]. An open-ended phrase allows the claim to include additional steps or elements that were not originally disclosed in the claim [94], such as the addition of another part of the whole apparatus as was the case with claims 1 and 15 described earlier in this thesis – the phrase in question is "comprising of". Because the open-ended phrase includes any additional steps or elements and therefore expands the scope of the claim [94], claim 1 allowed claim 15 to modify the apparatus without infringement. The last part of the patent claim is the body, consisting of a list of all parts protected by the claim and its limitations, and including how those parts interact with each other [95].

If the applicants were to use the phrase "consisting of" together with "and", it would be interpreted as a close-ended phrase, which explicitly states that the claim protects solely the parts described within the said claim and none other. This would enable possible infringement, as it allows the apparatus to be patentable again if additional parts were added [94], and can be seen in the second example:

"13. A chimeric coronavirus S protein selected from the group consisting of (a) amino acids 1-352 of a FIPV strain fused to amino acids 353-1454 of a FECV strain, (...) and (d)

amino acids 1-352 of a FIPV strain fused to amino acids 353-870 of a FECV strain fused to amino acids 871-1454 of a FIPV strain" (US07/882,171)

Another example of the importance of the use of proper vocabulary when drafting a patent would be the use of the noun "plurality" in place of "amount" which can be seen throughout the whole document. However, this is not consistent with the second example:

"18. A vaccine composition comprising an immunogenic amount of a chimeric coronavirus S protein or fragment thereof" (US07/882,171)

According to the Merriam-Webster dictionary, "*plurality*" refers to "*a large number or quantity*" or "*the state of being numerous*" [96] (which is essentially interchangeable), with one exception being in the context of a political election [97]. On the other hand, "*amount*" is more ambiguous, as it can be defined either as "*the total number or quantity*" or "*the whole effect, significance, or import*", with more definitions for a different word class. Though, in the case of the second example, the context of the claim leaves no room for this kind of misinterpretation.

3.3 Intertextuality in patent documentation

As is apparent, the field of industrial IP is highly intertextual. According to Burk and Reyman (2014), this begins with the references to the prior art, mentioned at the beginning of the documentation, and searches performed by both the applicant and the office. It further continues with the evaluation of novelty and inventiveness, even more so when the patent is a modification of a previous invention. The amount of intertextuality is further increased by any following communication regarding the application, as the patent in question is always referenced, especially if any appeals are made – adding even more intertextuality, as the patentee responds to these appeals and then the appellant responds to the patentee, with the cycle possibly continuing until a final decision is made. This can be observed at an earlier point in this thesis.

Another form of intertextuality is in the conventional form of patent documentation, as can be seen from the examples provided in this thesis [98]. Despite both being entirely different fields of science, different patent offices, and nearly two decades apart (in terms of submission dates), their structure is similar; they begin with an official form, followed by a short explanation of the field of the invention. Then, related art is explained, establishing a background for the invention, the basic concepts of which are explained afterward in the summary of the invention. Figures are described at the same points in both examples, and the detailed description of the invention following the description of the figures is made in the form of embodiments, accounting for all different configurations or modifications of the invention. At the end is the claims section; the style of which is consistent across the examples and is followed by a list of figures. However, there are also some differences. For example, the electrotechnical documentation heavily utilizes tables, equations, and images, whereas the medical documentation mostly references tables with molecular sequences. On the other hand, the figures are only referenced, not inserted in the text itself.

4. Conclusion

In this bachelor's thesis, various types of Intellectual Property often accompanying inventions were described as well as how to gain protection for them. An overview of the process of obtaining patent protection within the bodies available to Czech applicants was also provided, which was found to be a lengthy and bureaucratic process, as well as an insight on how such protection can be lost or even upfront unobtainable. According to the complexness of this field, the concept of patent representatives was also explained, together with the function of appeals in these matters. Finally, the possibility of losing a patent or the ability to obtain one was explored.

Furthermore, the impact of the COVID-19 pandemic on the field in question - especially in the matter of availability of medical supplies – was also included. This was done to further illustrate the impact the pandemic had on the entire world.

It was also found that the governing bodies (that is, on the national, European, and international levels) are highly cooperative.

Then, two different patent applications were analysed, with an emphasis on patent claims included within these applications – as they are the most important part of the whole. Furthermore, the nuances of the vocabulary of those claims were described, as well as providing insight on how easily an applicant can make a mistake. The documents were also found to be very intertextual, connected with other documents both by context and form. The analysis confirmed the original expectations about the language, which was found to be a formal mix of technical and legal English, which is devoid of any ambiguity.

Patent laws, and Intellectual Property in general, are irreplaceable and serve an important purpose and are perhaps even more important for future creators – after all, who would create and invent if his work can be easily stolen and/or abused?

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6. Appendices

1. Úřad Průmyslového Vlastnictví. Přihláška vynálezu se žádostí o udělení patentu (2021).

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PŘIHLÁŠKA VYNÁLEZU
se žádostí o udělení patentu

(Vyplní Úřad)

Pořadové číslo: ....

Spisová značka přihlášky: ....

Potvrzení o přijetí
vydáno dne: ....

MPT ....

Vyřizuje ....

Kód ....

DRUH PŘIHLÁŠKY

Přihláška NÁRODNÍ (Označte křížkem.) ☐	nebo ZAHRANIČNÍ ☐	
Přihláška PCT – národní fáze, číslo přihlášky PCT		Dat. mez. podání:
Žádost o PŘEMĚNU z EP na přihlášku národní, číslo přihlášky EP		Dat. EP podání:
Přihláška VYLOUČENÁ z původně podané PV, číslo přihlášky PV		

NÁZEV VYNÁLEZU

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PŘIHLAŠOVATEL (Pokud není možné uvést úplné údaje o kterémkoliv z vyplňovaných subjektů z důvodu nedostatku místa zde, použijte prosím k tomuto účelu doplňkový list formuláře.)

KŘÍŽKEM VYBERTE JEDNU MOŽNOST - zda se jedná o právnickou či fyzickou osobu a následně vyplňte údaje pouze v příslušném sloupci.

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POČET PŮVODCŮ ☐

PŮVODCE (V případě, že je původce současně i přihlašovatelem, není nutné požadované údaje u tohoto původce vyplňovat. Pokud není možné uvést úplné údaje o kterémkoliv z vyplňovaných subjektů z důvodu nedostatku místa zde, použijte prosím k tomuto účelu doplňkový list formuláře.)

Příjmení:	Titul před jm.:	Titul za jm.:
Jméno:	Datum nar.:	
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PŮVODCE si nepřeje být zveřejněn (Označte křížkem.) ☐		

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Jméno:	Datum nar.:	
Ulice a číslo:	Země (případně stát USA):	
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Jméno:	Datum nar.:	
Ulice a číslo:	Země (případně stát USA):	
Obec:	PSČ (jen pro ČR):	
PŮVODCE si nepřeje být zveřejněn (Označte křížkem.) ☐		

Příjmení:	Titul před jm.:	Titul za jm.:
Jméno:	Datum nar.:	
Ulice a číslo:	Země (případně stát USA):	
Obec:	PSČ (jen pro ČR):	
PŮVODCE si nepřeje být zveřejněn (Označte křížkem.)	☐	

ZÁSTUPCE PŘIHLAŠOVATELE

PŘIHLAŠOVATEL NENÍ ZASTOUPEN (Označte křížkem.) ☐

KŘÍŽKEM VYBERTE JEDNU MOŽNOST - zda se jedná o právnickou či fyzickou osobu dle plné moci a následně vyplňte údaje pouze v příslušném sloupci.

ZÁSTUPCE je:

PRÁVNICKÁ OSOBA ☐ IČ:	FYZICKÁ OSOBA ☐ Datum nar.:
Název / obchodní firma:	Příjmení:
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	Titul před jm.:
	Titul za jm.:
	IČ:
	Název kanceláře:

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Ulice a číslo:	
Obec:	
PSČ:	Země:
Datová schránka:	Tel.:
Fax:	E-mail:

Číslo prezidiální plné moci:	Číslo jednací zástupce:

Ev. č. ČAK:	Reg. č. KPZ:

PLNÁ MOC (Vyberte jednu z uvedených možností a označte křížkem.)

Byla již u Úřadu uložena jako prezidiální	☐
Zástupce požaduje její uložení u Úřadu jako prezidiální	☐
Na základě plné moci bude proveden u spisu zápis zástupce a plná moc nebude uložena jako prezidiální	☐

ADRESA PRO DORUČOVÁNÍ V ČR (VYPLŇUJE SE jen v případě, že jde o ADRESU ODLIŠNOU od adresy žadatele nebo zástupce.)

ADRESU pro doručování NELZE VYUŽÍT, MÁ-LI přihlašovatel nebo zástupce DATOVOU SCHRÁNKU a povaha dokumentů jejich ODESLÁNÍ datovou schránkou NEVYLUČUJE.

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Jméno:		
Ulice a číslo:		
Obec:		
PSČ:		

PRÁVO PŘEDNOSTI PODLE MEZINÁRODNÍ SMLOUVY

Číslo přihlášky:		Číslo přihlášky:	
Datum podání přihlášky:		Datum podání přihlášky:	
Země / Úřad:		Země / Úřad:	
Číslo přihlášky:		Číslo přihlášky:	
Datum podání přihlášky:		Datum podání přihlášky:	
Země / Úřad:		Země / Úřad:	

POČET PATENTOVÝCH NÁROKŮ

PODNIKOVÝ VYNÁLEZ

Jedná se o PODNIKOVÝ VYNÁLEZ (Označte křížkem.) ANO ☐ NE ☐

NABÍDKA LICENCE

NABÍDKA LICENCE (Označte křížkem): ANO ☐ NE ☐

SEZNAM PŘÍLOH (Vybrané možnosti označte křížkem.)

3 x popis vynálezu	☐	3 x obrázek k anotaci	☐
3 x patentové nároky	☐	3 x výkresy	☐
3 x anotace	☐		

- Plná moc (Činí-li podání zástupce, je třeba plnou moc doložit v originále či ověřené kopii.) ☐

- Doklad o nabytí práva na patent	☐	počet	
- Prioritní doklad	☐	počet	
- Potvrzení o deponování mikroorganismů	☐	počet	
- Doplňující listy tiskopisu přihlášky	☐	počet	
- Další doklady	☐	počet	

ŽÁDOST O ÚPLNÝ PRŮZKUM (Není již nutné podávat samostatnou žádost o provedení úplného průzkumu.)

ŽÁDÁM O PROVEDENÍ ÚPLNÉHO PRŮZKUMU u této přihlášky vynálezu podle zákona č. 527/1990 Sb., o vynálezech a zlepšovacích návrzích, ve znění pozdějších předpisů.

(Označte křížkem.): ANO ☐ NE ☐

O úplný průzkum lze požádat buď při podání přihlášky (označením příslušného políčka ve formuláři křížkem) nebo formou samostatné žádosti kdykoli během následujících 36 měsíců.

SOUHLASÍM S PŘEDÁNÍM VÝSLEDKŮ REŠERŠE pro účely Pravidla 141 EPC přímo EPÚ

(Označte křížkem.): ANO ☐ NE ☐

***Vysvětlivky (poznámka)*:**

V případě, že budete z této přihlášky nárokovat právo přednosti v následné evropské patentové přihlášce a máte zájem, aby požadavek podle Pravidla 141 EPC, tj. předložení výsledků rešerše Evropskému patentovému úřadu (EPÚ) provedl přímo náš Úřad, pak příslušné políčko označte křížkem. Jinak musíte požadavku z Pravidla 141 EPC vyhovět sami.

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Správní poplatek za 11. a každý další patentový nárok je stanoven na 500,- Kč.

****ZPŮSOB PLATBY** (Vyberte jednu z uvedených možností a označte křížkem.)

- Složenkou	☐
- Převodem z účtu*	☐
- Hotově v pokladně Úřadu	☐
- Kolkem	☐

***Poznámka*:** Správní poplatek se platí při podání přihlášky.
Kolky lze platit pouze pro platby do 5 000,- Kč (včetně).
*) **Číslo účtu správních poplatků ÚPV: 3711-21526001/0710**
**) Ostatní informace jsou uvedeny v nápovědě.

Místo pro nalepení kolku

POZNÁMKA

Potvrzuji pravdivost a úplnost shora uvedených údajů a žádám o udělení patentu.

Vyberte jednu z uvedených možností a označte křížkem.

- Přihlašovatel (V případě více přihlašovatelů musí být uvedeny podpisy všech těchto přihlašovatelů.) ☐
- Zástupce ☐

Jméno a příjmení
(HŮLKOVÝM PÍSMEM)

Datum

Podpis
(u právnické osoby případně i razítko)

VAROVÁNÍ PŘED AKTIVITOU PODVODNÝCH SUBJEKTŮ

Podvodné faktury vyzývající k zaplacení poplatků | Rejstříky, které nesouvisí s oficiálními rejstříky průmyslových práv Úřadu průmyslového vlastnictví

- Úřad průmyslového vlastnictví upozorňuje **přihlašovatele a vlastníky průmyslových práv a jejich zástupce**, že mohou být **písemně nebo elektronicky osloveni** některými soukromými společnostmi s kontaktními údaji na území ČR nebo jiných států.
- **Nabízejí za různé poplatky** v různých měnách **zveřejnění, registraci či evidenci průmyslových práv v jejich rejstřících nebo databázích vedených na Internetu.**
- **Úřad průmyslového vlastnictví** opětovně **varuje,** že takovéto **služby nikterak nesouvisí** ani **s úředními rejstříky či databázemi vedenými Úřadem průmyslového vlastnictví,** ani s právní ochranou poskytovanou podle příslušných právních předpisů. Nevyužití nabízených služeb nemá žádné právní účinky týkající se platnosti průmyslových práv.

***Klamavé výzvy můžete zasílat na adresu:* fraud@upv.cz**

více na www.upv.cz

INFORMACE PRO PŘIHLAŠOVATELE VYNÁLEZŮ

Podání přihlášek a řízení o přihláškách vynálezů a práva a povinnosti vyplývající z patentů na vynálezy jsou upraveny zákonem č. 527/1990 Sb., o vynálezech a zlepšovacích návrzích, v platném znění, a vyhláškou č. 550/1990 Sb., o řízení ve věcech vynálezů a průmyslových vzorů, ve znění vyhlášky č. 21/2002 Sb., a dále pak zákonem č. 500/2004 Sb., správní řád, a zákonem č. 634/2004 Sb., o správních poplatcích, v platném znění. Formální úprava přihlášky je stanovena platnou Instrukcí předsedy Úřadu průmyslového vlastnictví.

Další text této Informace má pouze podpůrně zdůraznit vybrané aspekty dané problematiky a nemůže nahradit plný text právních norem.

O udělení patentu se žádá přihláškou vynálezu se žádostí o udělení patentu podanou na předepsaném formuláři u Úřadu průmyslového vlastnictví (dále jen Úřad). Přihlášku lze podat poštou, elektronicky nebo osobně v podatelně Úřadu. Přihláška musí obsahovat formulář žádosti o udělení patentu v jednom vyhotovení a dále pak popis vynálezu, nejméně jeden patentový nárok, případně výkresy, a anotaci, to vše ve trojím vyhotovení, z nichž jedno musí vyhovovat požadavkům pro tisk a reprodukci. Jedno z vyhotovení musí být podepsáno přihlašovatelem nebo jeho zástupcem.

V přihlášce musí být uvedeno, kdo je původcem předmětu přihlášky vynálezu.

Přihláška smí obsahovat jen jeden vynález nebo skupinu vynálezů navzájem spojených tak, že uskutečňují jedinou vynálezeckou myšlenku. Vynález musí být v přihlášce vynálezu vysvětlen tak jasně, aby jej mohl odborník uskutečnit.

Podáním přihlášky vzniká přihlašovateli právo přednosti. Právo přednosti, které vyplývá z mezinárodní smlouvy, musí přihlašovatel uplatnit již v přihlášce a na výzvu Úřadu je v jím stanovené lhůtě prokázat, jinak se k němu nepřihlíží.

Úřad podrobí přihlášku vynálezu předběžnému průzkumu, tj. zda neobsahuje zjevně nepatentovatelná řešení a zda nemá nedostatky, které brání jejímu zveřejnění. Po uplynutí 18 měsíců od vzniku práva přednosti Úřad přihlášku zveřejní a toto zveřejnění oznámí ve Věstníku Úřadu.

Úplný průzkum Úřad provede na žádost přihlašovatele či jiné osoby nebo jej může provést z moci úřední. Žádost o provedení úplného průzkumu musí být podána nejpozději do 36 měsíců od podání přihlášky vynálezu a nelze ji vzít zpět. Uvedenou lhůtu nelze prodloužit a její zmeškání nelze prominout.

Řízení o přihlášce vynálezu vede Úřad s přihlašovatelem nebo s jím stanoveným zástupcem. Původce vynálezu, pokud není současně přihlašovatelem, není účastníkem řízení.

Konkrétní výši správních poplatků za úkony prováděné Úřadem stanoví Sazebník správních poplatků, který je přílohou zákona č. 634/2004 Sb., o správních poplatcích vybíraných správními orgány České republiky, v platném znění. Správní poplatky se platí při podání a poplatek za každý požadovaný úkon musí být uhrazen samostatně.

Rozsah patentové ochrany je určen patentovými nároky.

Patent platí 20 let od podání přihlášky vynálezu. Účinky patentu nastávají ode dne oznámení o udělení patentu ve Věstníku Úřadu. Za udržování platnosti patentů je majitel povinen platit každoročně udržovací poplatky podle zákona č. 173/2002 Sb., o poplatcích za udržování patentů a dodatkových ochranných osvědčení pro léčiva a pro přípravky na ochranu rostlin a o změně některých zákonů.

Původce může písemně požádat Úřad, aby jeho jméno nebylo uvedeno při zveřejnění přihlášky vynálezu a oznámení o udělení patentu ve Věstníku Úřadu.

Bližší informace je možno získat v Informačním středisku Úřadu nebo na www.upv.cz.

DOPLŇKOVÝ LIST č.

PŘIHLAŠOVATEL

KŘÍŽKEM VYBERTE JEDNU MOŽNOST - zda se jedná o právnickou či fyzickou osobu a následně vyplňte údaje pouze v příslušném sloupci.

PŘIHLAŠOVATEL je:

PRÁVNICKÁ OSOBA ☐ IČ:	FYZICKÁ OSOBA ☐ Datum nar.:
Název / obchodní firma:	Příjmení:
	Jméno:
	Titul před jm.:
	Titul za jm.:
	IČ:
	PŘIHLAŠOVATEL je i PŮVODCE ANO ☐ NE ☐

SÍDLO / BYDLIŠTĚ

Ulice a číslo:	
Obec:	
PSČ (jen pro ČR):	Země (případně stát USA):
Datová schránka:	Tel.:
Fax:	E-mail:

PŮVODCE

Příjmení:	Titul před jm.:	Titul za jm.:
Jméno:	Datum nar.:	
Ulice a číslo:	Země (případně stát USA):	
Obec:	PSČ (jen pro ČR):	
PŮVODCE si nepřeje být zveřejněn (Označte křížkem.) ☐		

Příjmení:	Titul před jm.:	Titul za jm.:
Jméno:	Datum nar.:	
Ulice a číslo:	Země (případně stát USA):	
Obec:	PSČ (jen pro ČR):	
PŮVODCE si nepřeje být zveřejněn (Označte křížkem.) ☐		

PRÁVO PŘEDNOSTI PODLE MEZINÁRODNÍ SMLOUVY

Číslo přihlášky:		Číslo přihlášky:	
Datum podání přihlášky:		Datum podání přihlášky:	
Země / Úřad:		Země / Úřad:	

PŘIHLAŠOVATEL

KŘÍŽKEM VYBERTE JEDNU MOŽNOST - zda se jedná o právnickou či fyzickou osobu a následně vyplňte údaje pouze v příslušném sloupci.

PŘIHLAŠOVATEL je:	
PRÁVNICKÁ OSOBA ☐ IČ:	FYZICKÁ OSOBA ☐ Datum nar.:
Název / obchodní firma:	Příjmení:
	Jméno:
	Titul před jm.:
	Titul za jm.:
	IČ:
	PŘIHLAŠOVATEL je i PŮVODCE ANO ☐ NE ☐

SÍDLO / BYDLIŠTĚ

Ulice a číslo:	
Obec:	
PSČ (jen pro ČR):	Země (případně stát USA):
Datová schránka:	Tel.:
Fax:	E-mail:

PŮVODCE

Příjmení:	Titul před jm.:	Titul za jm.:
Jméno:	Datum nar.:	
Ulice a číslo:	Země (případně stát USA):	
Obec:	PSČ (jen pro ČR):	
PŮVODCE si nepřeje být zveřejněn (Označte křížkem.) ☐		

Příjmení:	Titul před jm.:	Titul za jm.:
Jméno:	Datum nar.:	
Ulice a číslo:	Země (případně stát USA):	
Obec:	PSČ (jen pro ČR):	
PŮVODCE si nepřeje být zveřejněn (Označte křížkem.) ☐		

PRÁVO PŘEDNOSTI PODLE MEZINÁRODNÍ SMLOUVY

Číslo přihlášky:		Číslo přihlášky:	
Datum podání přihlášky:		Datum podání přihlášky:	
Země / Úřad:		Země / Úřad:	

Nápověda pro vyplnění formuláře č. P01

PŘIHLÁŠKA VYNÁLEZU se žádostí o udělení patentu

DRUH PŘIHLÁŠKY

Vyplní se příslušný druh přihlášky vynálezu.

Křížkem se vyznačí, jedná-li se o přihlášku národní nebo o přihlášku zahraniční. Jedná-li se o mezinárodní přihlášku podle PCT, uvede se číslo přihlášky PCT a datum jejího podání; jedná-li se o přeměnu přihlášky EP na přihlášku národní, uvede se číslo přihlášky EP a datum jejího podání; a jedná-li se o přihlášku vyloučenou, uvede se číslo přihlášky vynálezu, ze které je tato přihláška vyloučená.

Vyplnit lze i více druhů přihlášky (podávaná přihláška je např. přihláškou vyloučenou z přihlášky původně podané jako mezinárodní přihláška podle PCT).

NÁZEV VYNÁLEZU

Uvede se úplný název vynálezu. Název musí být shodný s názvem uvedeným v popisu přihlášky vynálezu, musí být přesný a stručný a neměl by obsahovat více než 10 slov.

POČET PŘIHLAŠOVATELŮ

Uvede se počet přihlašovatelů.

PŘIHLAŠOVATEL

V tomto poli se uvedou předepsané údaje o osobě, která podává přihlášku. Údaje o zástupci se zde nevyplňují. Podatel přihlášky zde zvolí a vyplní pouze jednu z možností, tedy zda je právnickou nebo fyzickou osobou. Pokud je právnickou osobou, nevyplňuje sloupec s údaji o fyzické osobě a naopak. Za fyzickou osobu se považuje jak fyzická osoba podnikající, tak fyzická osoba nepodnikající.

Sídlo / Bydliště - podatel zde uvede aktuální údaje ve formě, jak jsou vedeny v příslušných rejstřících (např. obchodním, živnostenském).

Přihlašovatelem je osoba, která se v případě udělení patentu stává jeho majitelem.

U přihlašovatele musí být v žádosti uvedeno příjmení, jméno, popřípadě titul, v případě fyzické osoby, respektive název firmy a IČ v případě právnické osoby, a dále úplná adresa včetně PSČ a datové schránky, je-li zřízena, popřípadě číslo telefonu, fax, e-mail.

V případě, že sídlem přihlašovatele je USA, uvede se v jeho adrese členský stát federace.

V příslušném políčku se křížkem vyznačí, zda je přihlašovatel současně i původcem. Není-li přihlašovatel současně i původcem a nejedná-li se o podnikový vynález, musí přihlašovatel k žádosti přiložit doklad o nabytí práva na patent.

POČET PŮVODCŮ

Uvede se počet původců.

PŮVODCE

Vyplní se údaje o původci nebo původcích. Původcem je osoba, která svou tvůrčí prací předmět přihlášky vynálezu vytvořila.

Touto osobou je výlučně osoba fyzická; tato osoba však může být zároveň i přihlašovatelem.

U původce musí být v žádosti uvedeno příjmení, jméno, případně titul, a úplná adresa včetně PSČ.

V případě, že sídlem původce je USA, uvede se v jeho adrese i členský stát federace.

Pokud si původce nepřeje být spolu s přihláškou zveřejněn, vyznačí se tato skutečnost v příslušném políčku křížkem.

ZÁSTUPCE PŘIHLAŠOVATELE

Pokud přihlašovatel není zastoupen, pouze křížkem označí tuto možnost a další údaje v tomto poli nevyplňuje. Je-li zastoupen, je nutno vyplnit předepsané údaje o zástupci (advokát, patentový zástupce, zmocněnec dle zák. č. 500/2004 Sb., správního řádu). Zástupce zde zvolí a vyplní pouze jednu z možností, tedy zda je právnickou nebo fyzickou osobou, a to v souladu s plnou mocí. Pokud je právnickou osobou, nevyplňuje sloupec s údaji o fyzické osobě a naopak.

Další údaj o zástupci (advokát, patentový zástupce) se uvede také do řádku „Titul za jm.:“

Do názvu kanceláře se může vyplnit název, který zástupce užívá v obchodním styku, aniž by měl tento název uveden v obchodním či jiném rejstříku, a v případě, že má zástupce zřízenou datovou schránku, uvede se tato v příslušném poli.

Sídlo / Bydliště - zástupce zde uvede aktuální údaje ve formě, jak jsou vedeny v Advokátní komoře, Komoře patentových zástupců či v obchodním rejstříku.

Pokud má zástupce u Úřadu založenou prezidiální plnou moc, je třeba se na ni odkázat uvedením jejího čísla.

V případě, kde to stanovuje zákon (viz ustanovení § 70 zákona č. 527/1990 Sb., o vynálezech a zlepšovacích návrzích, v platném znění), je zastoupení přihlašovatele povinné (obligatorní zastoupení) a zástupcem může být oprávněný patentový zástupce nebo advokát. V případě nepovinného zastupování může být zástupcem patentový zástupce, advokát nebo jiná osoba, např. společný zmocněnec (zástupcem více přihlašovatelů může být například jeden z těchto přihlašovatelů). Je-li pro řízení o přihlášce vynálezu před Úřadem zástupce ustanoven, musí být spolu s přihláškou předložena jeho platná plná moc.

ADRESA PRO DORUČOVÁNÍ

Vyplňuje se jen v případě, že je odlišná od adresy přihlašovatele, v případě více přihlašovatelů, od adresy jejich společného zmocněnce nebo jeho / jejich zástupce a je požadováno zasílat korespondenci Úřadu na adresu v ČR. Pokud se bude doručovat na P.O. BOX, pak se „P.O. BOX“ s číslem napíše do pole „Ulice a číslo“.

Má-li přihlašovatel, společný zmocněnec nebo jeho/jejich zástupce datovou schránku nelze využít adresu pro doručování. Úřad je ze zákona povinen upřednostnit doručování do datové schránky přihlašovatele nebo jeho zástupce (ustanovení § 17 zákona č. 300/2008 Sb., o elektronických úkonech a autorizované konverzi dokumentů), pokud maximální velikost datové zprávy nepřesáhne 20 MB (ustanovení § 5 vyhlášky č. 194/2009 Sb., o stanovení podrobností užívání a provozování informačního systému datových schránek). Patentová listina se doručuje vždy poštou.

PRÁVO PŘEDNOSTI PODLE MEZINÁRODNÍ SMLOUVY

Uvede se uplatňované právo přednosti (priorita). Podle ustanovení § 27 zákona č. 527/1990 Sb., o vynálezech a zlepšovacích návrzích, v platném znění, musí přihlašovatel právo přednosti, které vyplývá z mezinárodní smlouvy, uplatnit již v přihlášce a současně musí, podle ustanovení § 4 vyhlášky č. 21/2002 Sb., o řízení ve věcech vynálezů a průmyslových vzorů, kterou se mění vyhláška Federálního úřadu pro vynálezy č. 550/1990 Sb., uvést číslo přihlášky, ze které se toto právo přednosti odvozuje, datum jejího podání a stát, ve kterém byla přihláška podle mezinárodní smlouvy podána, respektive, jedná-li se o přihlášku regionální (např. přihlášku podle Úmluvy o udělování evropských patentů), úřad, u kterého byla tato přihláška podána. Je-li to nezbytné, musí být toto právo na výzvu Úřadu prokázáno prioritním dokladem.

POČET PATENTOVÝCH NÁROKŮ

Uvede se celkový počet patentových nároků.

PODNIKOVÝ VYNÁLEZ

Křížkem se vyznačí, jedná-li se o podnikový vynález či nikoli. O podnikový vynález se podle ustanovení § 9 zákona č. 527/1990 Sb., o vynálezech a zlepšovacích návrzích, v platném znění, jedná tehdy, vytvořil-li původce vynález ke splnění úkolu z pracovního poměru, z členského nebo jiného obdobného pracovněprávního vztahu ke svému zaměstnavateli.

NABÍDKA LICENCE

Křížkem se v příslušném okénku vyznačí, existuje-li nabídka licence či nikoli. O nabídku licence se podle ustanovení § 19 zákona č. 527/1990 Sb., o vynálezech a zlepšovacích návrzích, v platném znění, jedná, prohlásí-li u Úřadu přihlašovatel, popřípadě majitel patentu, že komukoli poskytne právo k využití vynálezu. V tomto případě pak vznikne právo k využití každému, kdo nabídku licence přijme a písemně to sdělí přihlašovateli nebo majiteli patentu. Úřad nabídku licence vyznačí v rejstříku. Prohlášení o nabídce licence nelze vzít zpět. Za udržování patentu, k němuž majitel nabídl licenci, se platí správní poplatky v poloviční výši.

SEZNAM PŘÍLOH

Příslušné přikládané přílohy se v seznamu vyznačí křížkem. Potřebný počet exemplářů je u každé z příloh předepsaných v seznamu uveden jednotlivě. Pokud žádost při podání obsahuje další přílohy, uvede se jejich počet.

INFORMACE O VÝŠI SPRÁVNÍHO POPLATKU

Za podání přihlášky je třeba uhradit příslušný správní poplatek stanovený Sazebníkem správních poplatků, který je přílohou zákona č. 634/2004 Sb., o správních poplatcích, v platném znění. Zvolený způsob platby se vyznačí křížkem.

Správní poplatek za podání přihlášky vynálezu se platí při podání přihlášky a může být uhrazen kolkovými známkami (které lze použít pro platby pouze do výše 5 000,- Kč), v hotovosti v pokladně správních poplatků v budově Úřadu průmyslového vlastnictví či složenkou nebo převodem na účet správních poplatků Úřadu průmyslového vlastnictví číslo 3711-21526001/0710 s uvedením variabilního symbolu platby. Variabilní symbol (VS) je identifikací bezhotovostní platby a musí být vždy uveden. Jedná se o číselný kód, který je v případě přihlášky vynálezu (patentu) složený z číslice 1 a ze spisové značky přihlášky (např. PV 2000-1427 má VS 120001427).

POZNÁMKA

V tomto poli se uvedou další případné skutečnosti, které nebylo možné uvést v předchozích polích.

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Podpisem přihlašovatele, nebo jeho zástupce (u právnických osob je možné připojit i razítko, které však podpis nenahrazuje) se potvrdí úplnost a pravdivost v přihlášce uvedených údajů. Zároveň se křížkem vyznačí, zda přihlášku podává přihlašovatel nebo jím zvolený zástupce.

Bližší informace je možno získat v Informačním středisku Úřadu nebo na www.upv.cz.

UPOZORNĚNÍ:

Doporučujeme věnovat zvláštní pozornost vyplňování oddílů se jmény a adresami (původce, přihlašovatele, zástupce, adresy pro doručování). Úřad tyto údaje zavádí do databáze výpočetního systému a používá při písemném styku a při vydávání ochranných dokumentů, a to v té podobě, ve které jsou uvedeny na formuláři. Vyžádání dodatečné opravy se považuje za žádost o provedení změny, kterou lze provést pouze v průběhu řízení. Ve vydaném ochranném dokumentu lze provést opravu pouze v případě, že je chyba způsobena Úřadem.

Údaje o čtvrtém a dalším přihlašovateli, o čtvrtém a dalším původci a o pátém a dalším právu přednosti podle mezinárodní smlouvy se uvedou v doplňkovém listu.

ÚŘAD PRŮMYSLOVÉHO VLASTNICTVÍ
Antonína Čermáka 2a, 160 68 Praha 6 - Bubeneč
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Zde přihlašovatel uvede adresu, kam má být potvrzení o podání zasláno:

Zde přihlašovatel uvede adresu své datové schránky:

POTVRZENÍ O PODÁNÍ PŘIHLÁŠKY VYNÁLEZU

Úřad průmyslového vlastnictví potvrzuje, že dne ....

byla podána přihláška vynálezu o názvu

(název doplní přihlašovatel)

....

....

se žádostí o udělení patentu.

Přihláška vynálezu byla evidována pod spisovou značkou:

PV

(podpis odpovědného pracovníka, datum, razítko)

VAROVÁNÍ PŘED AKTIVITOU PODVODNÝCH SUBJEKTŮ

Podvodné faktury vyzývající k zaplacení poplatků | Rejstříky, které nesouvisí s oficiálními rejstříky průmyslových práv Úřadu průmyslového vlastnictví

- Úřad průmyslového vlastnictví upozorňuje **přihlašovatele a vlastníky průmyslových práv a jejich zástupce**, že mohou být **písemně nebo elektronicky osloveni** některými soukromými společnostmi s kontaktními údaji na území ČR nebo jiných států.
- **Nabízejí za různé poplatky** v různých měnách **zveřejnění, registraci či evidenci průmyslových práv v jejich rejstřících nebo databázích vedených na Internetu.**
- **Úřad průmyslového vlastnictví** opětovně **varuje,** že takovéto **služby nikterak nesouvisí** ani **s úředními rejstříky či databázemi vedenými Úřadem průmyslového vlastnictví,** ani s právní ochranou poskytovanou podle příslušných právních předpisů. Nevyužití nabízených služeb nemá žádné právní účinky týkající se platnosti průmyslových práv.

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(spisovou značku doplní přihlašovatel)

PV

(podpis odpovědného pracovníka, datum, razítko)

VAROVÁNÍ PŘED AKTIVITOU PODVODNÝCH SUBJEKTŮ

Podvodné faktury vyzývající k zaplacení poplatků | Rejstříky, které nesouvisí s oficiálními rejstříky průmyslových práv Úřadu průmyslového vlastnictví

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- **Nabízejí za různé poplatky** v různých měnách **zveřejnění, registraci či evidenci průmyslových práv v jejich rejstřících nebo databázích vedených na Internetu.**
- **Úřad průmyslového vlastnictví** opětovně **varuje,** že takovéto **služby nikterak nesouvisí** ani **s úředními rejstříky či databázemi vedenými Úřadem průmyslového vlastnictví,** ani s právní ochranou poskytovanou podle příslušných právních předpisů. Nevyužití nabízených služeb nemá žádné právní účinky týkající se platnosti průmyslových práv.

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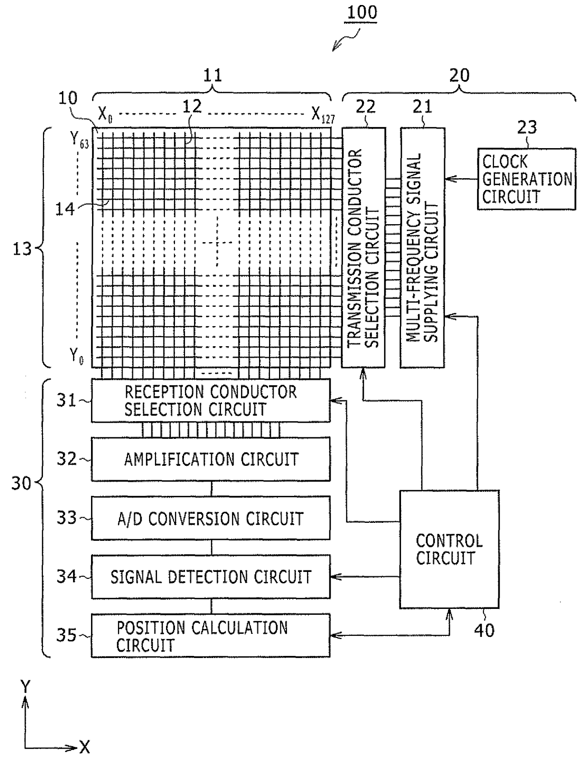
(54) **Pointer detection apparatus and pointer detection method**

(57) Disclosed herein is a pointer detection apparatus, including: a conductor pattern including a plurality of first conductors disposed in a first direction and a plurality of second conductors disposed in a second direction; a multi-frequency signal production circuit configured to produce a plurality of signals of different frequencies; a first conductor selection circuit configured to selectively supply the signals of different frequencies to those first conductors, between which N ones of the first conductors are interposed, N being a predetermined integer equal to or greater than 0; a second conductor selection circuit configured to selectively receive detection signals from the second conductors; and a signal detection circuit configured to obtain signals of individual frequencies, corresponding to the signals of different frequencies produced by the multi-frequency signal production circuit, which are representative of coupling states at cross points between the first conductors and the second conductors and are received from said second conductor selection circuit.

FIG. 1



EP 2 264 578 A1

Description

BACKGROUND

FIELD OF THE INVENTION

[0001] This invention relates to a pointer detection apparatus and a pointer detection method, and more particularly to a pointer detection apparatus and a pointer detection method wherein the position of a pointer is detected by an electrostatic coupling system.

DESCRIPTION OF THE RELATED ART

[0002] Conventionally, for the detection of the position of a pointer such as a finger or a pen for use with a touch panel or a like apparatus, various systems have been proposed such as, for example, a resistive film system, an electrostatic coupling system, and an electrostatic capacity system. In recent years, a pointer detection apparatus including the electrostatic coupling system, from among the various systems mentioned above, has been vigorously developed.

[0003] Electrostatic coupling systems are roughly divided into two types including a surface capacitive type and a projected capacitive type. An electrostatic coupling system of the surface capacitive type is applied, for example, in an ATM (Automated Teller Machine), and that of the projected capacitive type is applied, for example, in a portable telephone set. It is to be noted that, in both types, a variation of the electrostatic coupling state between a conductive film and a pointer such as a finger or an electrostatic pen is detected to detect the position of the pointer.

[0004] A pointer detection apparatus of the projected capacitive type electrostatic coupling system includes an electrode formed in a predetermined pattern, for example, on a transparent substrate or a transparent film and detects a variation of the electrostatic coupling state between a pointer and the electrode when the pointer approaches the electrode. For a pointer detection apparatus of the type described, various techniques for optimizing the configuration have been proposed and are disclosed, for example, in Japanese Patent Laid-Open Nos. HEI 5-224818, HEI 6-4213, HEI 7-141088, HEI 8-87369, HEI 8-179871, HEI 8-190453, HEI 8-241161, HEI 9-45184, 2000-76014, 2000-105645, 2000-112642, and HEI 10-161795.

[0005] Here, operation of a pointer detection apparatus of the cross point type electrostatic coupling system developed from the projected capacitive type electrostatic coupling system is described briefly with reference to the accompanying drawings. FIGS. 62A and 62B illustrate a general configuration of a sensor section and a position detection principle of a pointer detection apparatus of the cross point type electrostatic coupling system.

[0006] Referring to FIGS. 62A and 62B, a sensor section 300 includes a transmission conductor group 303 formed from a plurality of transmission conductors 304, and a reception conductor group 301 formed from a plurality of reception conductors 302. An insulating film is formed between the transmission conductor group 303 and the reception conductor group 301. The transmission conductors 304 extend in a predetermined direction indicated by an arrow mark X and are disposed in parallel to each other and in a spaced relationship by a predetermined distance from each other. The reception conductors 302 are in the form of a wire extending in a direction crossing the extension direction of the transmission conductors 304, that is, in the direction indicated by an arrow mark Y in FIG. 62A and are disposed in parallel to each other and in a spaced relationship at a predetermined distance from each other.

[0007] In the sensor section 300 having the configuration described above, a predetermined signal is supplied to a predetermined one of the transmission conductors 304 and a variation of current flowing to a cross point between the predetermined transmission conductors 304 and a reception conductor 302 is detected at each of the cross points of the predetermined transmission conductors 304 and the reception conductors 302. A system of detection just described is generally called cross point type electrostatic coupling system. At a position of the sensor section 300 at which a pointer 310 such as a finger is placed, current is shunted through the pointer 310 and varies. Therefore, the position of the pointer 310 can be detected by detecting a cross point at which current exhibits a variation. Further, in a pointer detection apparatus of the cross point type electrostatic coupling system, multipoint detection is possible because a plurality of cross points are provided on the sensor section 300 as seen in FIGS. 62A and 62B.

[0008] A principle of position detection of the cross point type electrostatic coupling system will now be described more particularly. Assume for example that a predetermined signal is supplied to the transmission conductor Y6 and a pointing position of the pointer 310 on the transmission conductor Y6 is detected as seen in FIG. 62A. When a signal is supplied to the transmission conductor Y6, the difference between currents flowing to the reception conductors X_0 and X_1 is detected through a differential amplifier 305. Then, after a predetermined interval of time, the reception conductors to be used for current difference detection are changed over from the reception conductors X_0 and X_1 to the reception conductors X_1 and X_2, and the current difference between the reception conductors X_1 and X_2 is detected. This operation is repeated up to the reception conductor X_M.

[0009] Thereupon, a level variation of an output signal of the differential amplifier 305 at the position of each cross point on the transmission conductor Y_6 is determined. FIG. 62B illustrates a characteristic of the level variation. In FIG. 62B, the axis of abscissa indicates the distance from the reception conductor X_0 to each reception conductor, that is, the position of each reception conductor, and the axis of ordinate indicates the level of an output signal of the differential amplifier 305, that is, an output value of the differential amplifier 305. In FIG. 62B, a broken line curve represents a characteristic of the level variation of the output signal of the differential amplifier 305 and a solid line curve represents a characteristic of the integration value of the output signal of the differential amplifier 305.

[0010] In the example illustrated in FIGS. 62A and 62B, since the pointer 310 is placed in proximity to cross points of the reception conductors X_4 and X_{M-5} on the transmission conductor Y_6, current flowing in proximity to the cross points varies. Therefore, in the example illustrated in FIG. 62B, the output signal of the differential amplifier 305 varies at corresponding positions in proximity to the cross points of the reception conductors X_4 and X_{M-5} on the transmission conductor Y_6, and the integration value of the output signal exhibits a low value, that is, a negative value. The position of the pointer 310 can be detected based on the variation of the integration value. In the conventional pointer detection apparatus, the detection described above is carried out while successively changing over between the transmission conductors, to be used for the detection, one by one.

SUMMARY

[0011] This summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This summary is not intended to identify key features of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter.

[0012] Since such a pointer detection apparatus of the cross point type electrostatic coupling system as described above carries out a position detection process of cross points one by one per every predetermined period of time, a long period of time is required for detection at all cross points. For example, if the sensor section includes 64 transmission conductors and 128 reception conductors and the detection processing time at each of the cross points is, for example, 256 μsec, then a period of time of approximately 2 seconds is required for detection at all cross points, that is, at 8,192 cross points in total. Therefore, the pointer detection apparatus as described above is not suitable for practical use.

[0013] Therefore, it is an object of the present invention to provide a pointer detection apparatus and a pointer detection method by which detection of the position of a pointer by an electrostatic coupling system can be carried out at a higher speed.

[0014] To that end, a pointer detection apparatus is described that includes a conductor pattern with a plurality of conductors disposed in a first direction and a plurality of conductors disposed in a second direction which crosses the first direction. The apparatus further includes a multi-frequency signal production circuit configured to produce a plurality of signals of different frequencies, and a first conductor selection circuit configured to selectively supply said signals of different frequencies produced by the multi-frequency signal production circuit to those first conductors, between which N number of the first conductors are interposed, N being a predetermined integer equal to or greater than 0. The apparatus still further includes a second conductor selection circuit configured to selectively receive detection signals from the plurality of second conductors, and a signal detection circuit configured to detect signals of individual frequencies, corresponding to the signals of different frequencies produced by the multi-frequency signal production circuit, which are representative of coupling states at cross points between the first conductors and the second conductors and are received from said second conductor selection circuit.

[0015] According to another aspect of the present invention, a pointer detection method is described that includes: a first step of producing a plurality of signals of different frequencies; and a second step of selectively supplying the signals of different frequencies to a conductor pattern including a plurality of first conductors disposed in a first direction and a plurality of second conductors disposed in a second direction crossing the first direction. Specifically, the second step selectively supplies the signals of different frequencies to those first conductors, between which N number of the first conductors are interposed, N being a predetermined integer equal to or greater than 0. The method further includes a third step of selectively switching those second conductors from which detection signals are to be received; and a fourth step of obtaining signals of individual frequencies, corresponding to the signals of different frequencies produced at the first step, based on the detection signals supplied from the second conductors selected at the third step. The obtained signals of individual frequencies are representative of coupling states at cross points between the first conductors and the second conductors.

[0016] In the pointer detection apparatus and the pointer detection method, a plurality of signals having frequencies different from each other are supplied at the same time to the plurality of conductors on the transmission side. Meanwhile, on the reception side, signals of individual frequencies corresponding to the plurality of signals having different frequencies are detected to determine the position of a pointer on the conductor pattern. In other words, signal processing is executed in parallel between (among) the conductors on both of the transmission side and the reception side.

[0017] A plurality of signals of different frequencies are supplied at the same time to the plurality of conductors on the transmission side to detect the position of a pointer on the conductor pattern. In other words, the position detection process can be carried out at the same time for a plurality of cross points. Therefore, the present invention makes it possible for a pointer detection apparatus of the electrostatic coupling system to carry out position detection of a pointer at a higher speed.

[0018] Furthermore, the present invention makes it possible for a pointer detection apparatus of the electrostatic coupling system to carry out position detection of multiple positions (i.e., multiple positions of multiple pointers, or of multiple fingers of one or more users) at the same time.

[0019] The above and other objects, features, and advantages of the present invention will become apparent from the following description and the appended claims, taken in conjunction with the accompanying drawings.

DESCRIPTION OF THE DRAWINGS

[0020] The foregoing aspects and many of the attendant advantages of this invention will become more readily appreciated as the same become better understood by reference to the following detailed description, when taken in conjunction with the accompanying drawings, wherein:

FIG. 1 is a schematic block diagram of a pointer detection apparatus according to a first embodiment of the present invention;
FIG. 2 is a schematic sectional view of a sensor section of the pointer detection apparatus of FIG. 1;
FIG. 3 is a block diagram of a multi-frequency signal supplying circuit of the pointer detection apparatus of FIG. 1;
FIG. 4 is a block diagram of a periodic signal production section of the pointer detection apparatus of FIG. 1;
FIG. 5 is a diagrammatic view of a transmission conductor selection circuit of the pointer detection apparatus of FIG. 1;
FIG. 6 is a diagrammatic view illustrating switching operation of transmission conductors in the pointer detection apparatus of FIG. 1;
FIG. 7 is a diagrammatic view of a reception conductor selection circuit and an amplification circuit of the pointer detection apparatus of FIG. 1;
FIG. 8 is a diagrammatic view illustrating switching operation of reception conductors in the pointer detection apparatus of FIG. 1;
FIG. 9 is a block diagram of a reception section of the pointer detection apparatus of FIG. 1;
FIG. 10 is a block diagram of a synchronous detection circuit section of the pointer detection apparatus of FIG. 1;
FIG. 11A is a schematic view illustrating an electrostatic coupling state between a transmission conductor and a reception conductor where no pointer exists on the sensor section shown in FIG. 2, and FIG. 11B is a similar view but illustrating another electrostatic coupling state between the transmission conductor and the reception conductor where a pointer exists on the sensor section shown in FIG. 2;
FIG. 12A is a schematic view illustrating a multi-touch state of the pointer detection apparatus of FIG. 1, and FIGS. 12B, 12C and 12Dare waveform diagrams respectively illustrating a waveform of output signals of the reception conductors on a transmission conductor, another detection waveform of output signals of the reception conductors on another transmission conductor, and a further detection waveform of output signals of the reception conductors on a further transmission conductor;
FIG. 13 is a flow chart illustrating a procedure for position detection by the pointer detection apparatus of FIG. 1;
FIG. 14 is a schematic sectional view of the sensor section according to modification 1 to the pointer detection apparatus of FIG. 1;
FIG. 15A is a schematic sectional view of the sensor section according to modification 2 to the pointer detection apparatus of FIG. 1, and FIG. 15B is a perspective view of the sensor section shown in FIG. 15A;
FIG. 16A is a schematic enlarged view of a cross point of the sensor section of a first example according to modification 3 to the pointer detection apparatus of FIG. 1, and FIG. 16B is a schematic further enlarged view of a land conductor portion of the sensor section shown in FIG. 16A;
FIG. 17 is a schematic enlarged view of the sensor section of a second example according to modification 3 to the pointer detection apparatus of FIG. 1;
FIG. 18 is a schematic view showing a configuration of the sensor section according to modification 4 to the pointer detection apparatus of FIG. 1;
FIG. 19A is a schematic view showing an upper conductor pattern of the sensor section shown in FIG. 18, and FIG. 19B is a schematic view showing a lower conductor pattern of the sensor section shown in FIG. 18;
FIG. 20 is a schematic view showing a configuration of the sensor section according to modification 5 to the pointer detection apparatus of FIG. 1;
FIG.21A is a schematic circuit diagram of an amplifier according to modification 6 to the pointer detection apparatus of FIG. 1, and FIG. 21B is a block diagram of the amplification circuit where a differential amplifier is used and associated elements of the amplification circuit;
FIG. 22 is a schematic circuit diagram of the amplifier according to modification 7 to the pointer detection apparatus

of FIG. 1;
FIG. 23 is a schematic circuit diagram illustrating a supplying form of periodic signals according to modification 8 to the pointer detection apparatus of FIG. 1;
FIG. 24 is a similar view but illustrating a supplying form of periodic signals and a detection form of an output signal according to modification 9 to the pointer detection apparatus of FIG. 1;
FIGS. 25A and 25B are diagrammatic views illustrating an example of rotation of the frequencies of periodic signals according to modification 9 to the pointer detection apparatus of FIG. 1;
FIGS. 26A to 26C are diagrammatic views illustrating another example of rotation of the frequencies of periodic signals according to modification 9 to the pointer detection apparatus of FIG. 1;
FIG. 27 is a diagrammatic view illustrating a level curve detected in modification 9 to the pointer detection apparatus of FIG. 1;
FIG. 28 is a similar view but illustrating an example of a supplying form of periodic signals and a detection form of an output signal according to modification 10 to the pointer detection apparatus of FIG. 1;
FIG. 29 is a diagrammatic view showing another example of a supplying form of periodic signals and a detection form of the output signal according to modification 10 to the pointer detection apparatus of FIG. 1;
FIG. 30 is a diagrammatic view showing an example of a supplying form of periodic signals and a detection form of an output signal according to modification 11 to the pointer detection apparatus of FIG. 1;
FIG. 31 is a similar view but showing another example of a supplying form of periodic signals and a detection form of an output signal according to modification 11 to the pointer detection apparatus of FIG. 1;
FIG. 32 is a similar view but showing a further example of a supplying form of periodic signals and a detection form of an output signal according to modification 11 to the pointer detection apparatus of FIG. 1;
FIGS. 33A and 33B are diagrammatic views showing different examples of a supplying form of periodic signals and a detection form of an output signal according to modification 12 to the pointer detection apparatus of FIG. 1;
FIG. 34 is a schematic diagrammatic view illustrating a signal level upon normal detection of a finger;
FIG. 35 is similar view but illustrating an example of a level curve after a nonlinear process for the signal of the signal level of FIG. 34, according to modification 13 to the pointer detection apparatus of FIG. 1;
FIG. 36 is a diagrammatic view illustrating an example of normalized levels of output signals detected by the reception section according to modification 14 to the pointer detection apparatus of FIG. 1;
FIGS. 37 and 38 are diagrammatic views illustrating examples of a supplying form of periodic signals and a detection form of an output signal according to modification 15 to the pointer detection apparatus of FIG. 1;
FIG. 39 is a diagrammatic view showing a supplying form of periodic signals and a detection form of an output signal and illustrating a problem to be solved by modification 17 to the pointer detection apparatus of FIG. 1;
FIG. 40 is a similar view but showing an example of a supplying form of periodic signals and a detection form of the output signal according to modification 17 to the pointer detection apparatus of FIG. 1;
FIG. 41 is a block diagram of the reception section of the pointer detection apparatus according to modification 18 to the pointer detection apparatus of FIG. 1;
FIG. 42 is a block diagram of an absolute value detection circuit of the pointer detection apparatus according to modification 18 to the pointer detection apparatus of FIG. 1;
FIG. 43A is a diagrammatic view illustrating a supplying state of periodic signals upon one-sided transmission and FIG. 43B is a diagrammatic view illustrating the level of output signals;
FIG. 44A is a diagrammatic view illustrating a supplying form of periodic signals upon double-sided transmission according to modification 19 to the pointer detection apparatus of FIG. 1 and FIG. 44B is a diagrammatic view illustrating the level of output signals;
FIG. 45A is a schematic view illustrating an example or a spatial distribution or level curved face of output signals and FIG. 45B is a view illustrating division of the level curved face into a plurality of planes according to modification 19;
FIG. 46 is a graph illustrating an example of a method of calculating the volume of a level curved face according to modification 20 to the pointer detection apparatus of FIG. 1;
FIG. 47 is a schematic block diagram of a pointer detection apparatus according to a second embodiment of the present invention;
FIG. 48 is a schematic view of a transmission conductor selection circuit and a transmission conductor connection pattern changeover circuit of the pointer detection apparatus of FIG. 47;
FIGS. 49A and 49B are diagrammatic views illustrating switching operation of transmission conductors of the pointer detection apparatus of FIG. 47;
FIG. 50 is a diagrammatic view of a reception conductor selection circuit and a reception conductor connection pattern changeover circuit of the pointer detection apparatus of FIG. 47;
FIG. 51 is a diagrammatic view illustrating switching operation of reception conductors by the pointer detection apparatus of FIG. 47;
FIGS. 52A and 52B are diagrammatic views illustrating an example of switching operation of transmission conductors

by a pointer detection apparatus according to a third embodiment of the present invention;

FIGS. 53A and 53B are diagrammatic views illustrating another example of switching operation of transmission conductors by the pointer detection apparatus according to the second embodiment of the present invention;

FIG. 54 is a schematic block diagram of a pointer detection apparatus according to a fourth embodiment of the present invention;

FIG. 55 is a waveform diagram illustrating an example of dispersion of initial phases of periodic signals;

FIG. 56 is a graph illustrating a composite waveform of transmission signals by the pointer detection apparatus of FIG. 54 where no phase dispersion is applied;

FIGS. 57 to 61 are graphs illustrating composite waveforms of transmission signals by the pointer detection apparatus of FIG. 54 where different patterns of phase dispersion are applied; and

FIG. 62A is a schematic view of a sensor section of a conventional pointer detection apparatus of the cross point type electrostatic coupling system, and FIG. 62B is a view illustrating a principle of position detection by the conventional cross point type pointer detection apparatus of FIG. 62A.

DETAILED DESCRIPTION

[0021] Several embodiments of the present invention will be described with reference to the accompanying drawings. One skilled in the art will appreciate that the present invention is not limited to the described embodiments; the descriptions are provided for illustrative purposes only. The description is given in the following order.

1. First Embodiment (example of scanning within a group in the frequency multiplexing system);
2. Second Embodiment (example of scanning while switching between block units in the frequency multiplexing system);
3. Third Embodiment (example of scanning of all conductors in the frequency multiplexing system); and
4. Fourth Embodiment (example wherein initial phases of multi-frequency signals are dispersed in the frequency multiplexing system).

<1. First Embodiment>

[0022] A first embodiment of the present invention relates to a basic configuration of a pointer detection apparatus and a pointer detection method of the present invention.

[0023] In the present embodiment, each of a transmission conductor group and a reception conductor group of a sensor section is divided into a plurality of groups, and signals in the form of periodic signals having frequencies different from each other among the different groups are supplied simultaneously, that is, multiplex transmitted. In the following description, the supplying form of signals in the present embodiment is referred to as "frequency multiplex system" or "frequency multiplex type," and a plurality of periodic signals supplied are generally referred to as "multi-frequency signal." The position detection system in the present invention is an electrostatic coupling system wherein the position of a pointer is detected based on a variation of the electrostatic coupling state between a transmission conductor and a reception conductor of the sensor section.

[Configuration of the Pointer (i.e., Position Indicator) Detection Apparatus]

[0024] FIG. 1 shows a general configuration of the pointer detection apparatus according to the first embodiment of the present invention.

[0025] Referring to FIG. 1, a pointer detection apparatus 100 shown includes, as principal components thereof, a sensor section 10, a transmission section 20, a reception section 30, and a control circuit 40 for controlling operation of the transmission section 20 and the reception section 30. In the following, the components are described individually.

[0026] First, the configuration of the sensor section 10 is described with reference to FIGS. 1 and 2. FIG. 2 is a cross sectional view as viewed from along the direction indicated by an arrow marked X in FIG. 1. Referring first to FIG. 2, the sensor section 10 includes a first glass substrate 15, a reception conductor group 11 including a plurality of reception conductors 12, a spacer 16, a transmission conductor group 13 including a plurality of transmission conductors 14, and a second glass substrate 17. The transmission conductor group 13, spacer 16, reception conductor group 11 and second glass substrate 17 are formed in this order on the first glass substrate 15.

[0027] In the first embodiment, a pointer such as a finger or an electrostatic pen is used on the second glass substrate 17 side, that is, on the side opposite the face of the second glass substrate 17 that opposes the first glass substrate 15. Further, in the first embodiment, a substrate in the form of a sheet or film made of a synthetic resin or the like may be used in place of the first glass substrate 15 or the second glass substrate 17.

[0028] Each of the transmission conductors 14 and the reception conductors 12 is formed from a transparent electrode film, for example, of an ITO (Indium Tin Oxide), a copper foil, or the like. The electrode patterns of the transmission conductors 14 can be formed, for example, in the following manner. First, an electrode film formed from any of the materials described above is formed on the first glass substrate 15, for example, by sputtering, vapor deposition or application. Then, the electrode film is etched to form predetermined electrode patterns. Electrode patterns of the reception conductors 12 can be formed on the second glass substrate 17 in a similar manner. Where the transmission conductors 14 and the reception conductors 12 are formed from a copper foil, it is possible to use an ink jet printer to spray ink including copper particles in predetermined electrode patterns to a glass plate or the like to produce the conductors.

[0029] The spacer 16 may be formed from a synthetic resin material such as, for example, PVB (PolyVinyl Butyral), EVA (Ethylene Vinyl Acetate), an acrylic-based resin or the like. The spacer 16 may otherwise be formed from silicon rubber of a high refractive index, that is, from a high dielectric.

[0030] Where the spacer 16 is formed from a synthetic resin, it can be formed, for example, in the following manner. First, a synthetic resin sheet is sandwiched between the transmission conductors 14 and the reception conductors 12. Then, while evacuation between the conductors is carried out, pressurization and heating are carried out to form the spacer 16. As another example, a synthetic resin in the form of liquid may be supplied into a space between the transmission conductors 14 and the reception conductors 12, whereafter it is solidified to form the spacer 16.

[0031] Referring back to FIG. 1, the transmission conductor group 13 includes a plurality of transmission conductors 14 extending in a predetermined direction, indicated by an arrow mark X, and the transmission conductors 14 are disposed in parallel to each other and in a spaced relationship at a predetermined distance from each other. Meanwhile, the reception conductor group 11 includes a plurality of reception conductors 12 extending in a direction perpendicular to the extension direction of the transmission conductors 14, that is, in the direction indicated by an arrow mark Y in FIG. 1. The reception conductors 12 are disposed in parallel to each other and in a spaced relationship from each other. The transmission conductors 14 and the reception conductors 12 may each be formed from a conductor of a linear or plate shape or some other predetermined shape. In the first embodiment, the transmission conductors 14 and the reception conductors 12 are each formed in a linear shape. While in FIG. 1 the transmission conductors 14 and the reception conductors 12 are shown extending perpendicularly to each other, they may otherwise cross each other at an angle other than the right angle, for example, in an obliquely crossing relationship with each other. From an electric characteristic, the reception conductors should be formed with a width smaller than that of the transmission conductors. This will decrease the floating capacitance to thereby reduce noise, which may appear in the reception conductor.

[0032] In the first embodiment, the number of transmission conductors 14 is 64 and the number of reception conductors 12 is 128. Further, the disposition distance, that is, the pitch, of both of the transmission conductors 14 and the reception conductors 12 is 3.2 mm. However, the present invention is not limited to the configuration just described, and the number and the pitch of each of the transmission conductors 14 and the reception conductors 12 is set suitably in accordance with the size of the sensor section 10, required detection accuracy, and so forth.

[0033] The transmission conductors 14 in the transmission conductor group 13 are represented by indexes n from "0" to "63" in order, beginning with that of the transmission conductors 14 which is positioned nearest to the reception section 30. In the following description, a transmission conductor 14 corresponding to the index n is referred to as transmission conductor Y_n. The reception conductors 12 in the reception conductor group 11 are represented by index m from "0" to "127" in order, beginning with that of the reception conductors 12, which is positioned farthest from the transmission section 20. In the following description, a reception conductor 12 corresponding to the index m is referred to as reception conductor X_m.

[0034] Further, each of the transmission conductor group 13 and the reception conductor group 11 is divided into 16 groups or blocks. A group of the transmission conductor group 13 is hereinafter referred to as transmission block, and a group of the reception conductor group 11 is hereinafter referred to as detection block.

[0035] The transmission block includes four transmission conductors 14. In particular, each transmission block includes four transmission conductors 14 which are positioned adjacent to each other and have consecutive indexes n. More particularly, in the present embodiment, the transmission conductor group 13 is divided into blocks {Y_0 to Y_3}, {Y_4 to Y_7}, ..., {Y_{56} to Y_{59}} and {Y_{60} to Y_{63}}.

[0036] Similarly, the detection block includes eight reception conductors 12. In particular, each detection block includes eight reception conductors 12 which are positioned adjacent to each other and have consecutive indexes m. More particularly, the reception conductor group 11 is divided into blocks {X_0 to X_7}, {X_8 to X_{15}}, ..., {X_{112} to X_{119}} and {X_{120} to X_{127}}.

[0037] However, the present invention is not limited to the configuration just described. The number of conductors in one group, the number of groups, and the form of groups such as the positional relationship of the conductors belonging to the same group may be set suitably in accordance with the size of the sensor section 10, the required detection speed, and so forth. Details are hereinafter described.

[0038] The transmission section 20 includes a transmission conductor selection circuit 22, a multi-frequency signal supplying circuit 21 and a clock generation circuit 23. The transmission conductor selection circuit 22, multi-frequency signal supplying circuit 21 and clock generation circuit 23 are formed in this order from the sensor section 10 side. The multi-frequency signal supplying circuit 21 is connected to the clock generation circuit 23 and controlled by a clock signal output from the clock generation circuit 23.

[0039] FIG. 3 shows an example of a general configuration of the multi-frequency signal supplying circuit 21.

[0040] Referring to FIG. 3, the multi-frequency signal supplying circuit 21 in the first embodiment includes a number of periodic signal production sections 24 equal to the number of the transmission blocks of the reception conductor group 11, that is, 16 periodic signal production sections 24. The periodic signal production sections 24 individually produce a periodic signal of a fixed period under the control of the control circuit 40. In the first embodiment, the periodic signals produced by the periodic signal production sections 24 are denoted by indexes i from "0" to "15" in order beginning with that of the periodic signal production sections 24 that is positioned nearest to the reception section 30. The 16 periodic signals have 16 different frequencies different by 10 kHz from each other, for example, from 100 kHz to 250 kHz.

[0041] FIG. 4 shows a general configuration of the periodic signal production section 24. Referring to FIG. 4, the periodic signal production section 24 includes, as principal components thereof, an adder 241, a selector 242, a D-type flip-flop (hereinafter referred to as D-FF) 243, a rectangular wave ROM 244 and another D-FF 245. These components are individually described below.

[0042] The adder 241 has a pair of input terminals and a single output terminal for outputting a result of arithmetic operation. To one of the input terminals of the adder 241, Frequency data which is a skipping over number designation signal is input from a register not shown. The frequency data is a digital signal indicative of one frequency within the range from 100 kHz and 250 kHz and is set for each of the periodic signal production sections 24 by the control circuit 40. An arithmetic operation result output from the output terminal of the adder 241 is input to the D-FF 243 through the selector 242, and an output of the D-FF 243 is input to the other input terminal of the adder 241.

[0043] The selector 242 has a pair of input terminals and a single output terminal for outputting a result of arithmetic operation. An arithmetic operation result from the adder 241 is input to one of the input terminals of the selector 242. Initial phase data is input from a register (not shown) to the other input terminal of the selector 242. The selector 242 selectively outputs one of the arithmetic operation result and the initial phase data input thereto. The initial phase data is a digital signal representative of, for example, 22.5°, 45° or 90°, and is set for each of the periodic signal production sections 24 by the control circuit 40. In the present embodiment, the initial phase is 0°.

[0044] The D-FF 243 temporarily retains data input thereto from the selector 242. To the D-FF 243, also a clock generated by the clock generation circuit 23 is input. The D-FF 243 stores data input thereto from the selector 242 at a timing of an edge of the clock input thereto from the clock generation circuit 23. An output of the D-FF 243 is input to the rectangular wave ROM 244 and also to the adder 241.

[0045] The rectangular wave ROM 244 is a ROM (Read Only Memory) in which data of, for example, a pseudo rectangular wave of 8 bits × 256 samples is stored. In the periodic signal production section 24, the control circuit 40 or a special readout section designates an address of the rectangular wave ROM 244 in response to a signal input thereto from the D-FF 243, based on a clock supplied from the clock generation circuit 23, to read out data from the rectangular wave ROM 244. If the frequency data and the initial phase data from the registers change, the address of the rectangular wave ROM 244 from which data is to be output changes, and the frequency data and the initial phase of rectangular wave data to be output from the rectangular wave ROM 244 also change.

[0046] In order to make it possible to produce a plurality of frequencies, when an address for reading out data from the rectangular wave ROM 244 is designated, the periodic signal production section 24 designates the number of addresses to be skipped. Where data of the rectangular wave ROM 244 is to be read out using, for example, a 2.56-MHz clock without skipping out addresses at all, the frequency of a rectangular wave to be read out becomes 2.56 MHz ÷ 256 = 10 kHz. Where skipping out addresses is to be carried out by one address to read out data of the rectangular wave ROM 244 using a 2.56-MHz clock, the frequency of the rectangular wave to be read out is 2.56 MHz ÷ (256 ÷ 2) = 20 kHz. In other words, if the number of addresses to be skipped increases, the frequency also increases. The numerical value examples given above are a mere illustration, and the numerical values are not limited to them.

[0047] The D-FF 245 temporarily retains rectangular wave data input thereto from the rectangular wave ROM 244. The D-FF 245 outputs the temporarily retained rectangular wave data to the transmission conductor selection circuit 22 based on a clock data supplied thereto from the clock generation circuit 23.

[0048] An operation of the periodic signal production section 24 will now be described. In the periodic signal production section 24 configured in a manner described above, if a reset signal output from the control circuit 40 is input to the selector 242, then the selector 242 selects the initial phase. Then, a signal representative of the initial phase selected by the selector 242 is input to the D-FF 243, by which the initial phase is set. The former process (i.e., selection of the initial phase) is carried out earlier than a rising edge of the clock, and the latter process (i.e., inputting of the selected initial phase) is carried out later than the rising edge of the clock.

[0049] Then, the D-FF 243 inputs a signal representative of the initial phase to the adder 241 based on a clock generated by the clock generation circuit 23. The adder 241 carries out a process of adding the frequency data, which is a skipping out designation signal, to the signal input thereto from the D-FF 243 and representative of the initial phase.

The adder 241 outputs a result of arithmetic operation thereof to the D-FF 243 through the selector 242. The arithmetic operation result, that is, the addition value obtained by the addition of the signal of the initial phase and the frequency data, is set in the D-FF 243. The addition value is supplied from the D-FF 243 to the rectangular wave ROM 244. Then, an address corresponding to the addition value is designated based on a clock generated by the clock generation circuit 23. Data is output from the rectangular wave ROM 244 in response to the designated address. The read out data is output to the transmission conductor selection circuit 22 through the D-FF 245. Thereafter, the loop process from the D-FF 243 to the adder 241 is repeated to carry out the addition process for a number of times equal to the number of the frequency data. By repeating a sequence of operations described above, rectangular wave data of an object frequency and an initial phase are obtained.

[0050] The first embodiment described is directed to a case where the periodic signals to be supplied to the transmission conductors have a rectangular waveform, which is a pulse waveform exhibiting upward and downward potential variations with respect to a reference potential of 0 volt. However, any periodic signal may be used as long as it has a fixed period. For example, the rectangular wave ROM 244 may be replaced by a sine wave ROM or a pulse wave ROM so as to produce a sine wave or a pulse wave, which is a rectangular wave oscillating between the 0 volt and another potential Vcc or which may be a negative signal having a polarity reversed from that of the rectangular wave. The rectangular wave described above may be regarded as a rectangular wave which oscillates upwardly and downwardly with reference to a potential, which is equal to one half the potential Vcc of the pulse wave. The periodic signal production section 24 may naturally be implemented without using various ROMS as described above.

[0051] Further, although, in the first embodiment, the initial phase of the periodic signals is set to 0°, and any of the initial phase and the frequency is not changed after it is set once, the frequency and the initial phase of the frequency signals to be produced by the periodic signal production section 24 are not limited to those of the example just described. Although the periodic signal production section 24 outputs the periodic signal at a certain timing, the periodic signal production section 24 is not limited to that example. Other examples are hereinafter described.

[0052] The selected one of the transmission conductors 14, to which a periodic signal is to be supplied, is changed over by the transmission conductor selection circuit 22 under the control of the control circuit 40. The transmission conductor selection circuit 22 in the first embodiment is formed of a number of switches equal to the number of groups of the transmission conductor group 13, that is, of 16 switches.

[0053] FIG. 5 shows an internal configuration of the transmission conductor selection circuit 22. Referring to FIG. 5, the transmission conductor selection circuit 22 includes a plurality of switches 22a for selectively supplying a periodic signal supplied thereto from the multi-frequency signal supplying circuit 21. The switches 22a are provided in a one-by-one corresponding relationship to transmission blocks 25. Each of the switches 22a has four terminals 22b on the output side thereof, which are individually connected to corresponding ones of the transmission conductors 14. Each of the switches 22a has one terminal 22c on the input side thereof, which is connected to an output terminal of a corresponding one of the periodic signal production sections 24 of the multi-frequency signal supplying circuit 21 shown in FIG. 3. Each of the switches 22a connects, at a predetermined interval of time, a selected one of the transmission conductors 14 and a terminal of a corresponding one of the periodic signal production sections 24, which outputs a frequency signal of a predetermined frequency f_k (k = 0 to 15), to each other. The changeover (switching) operation of the switches 22a is controlled by the control circuit 40.

[0054] FIG. 6 illustrates an example of the changeover (switching) operation of the transmission conductors 14 in the first embodiment. Referring to FIG. 6, the selected one of the transmission conductors 14, which has the highest index in each of the transmission blocks 25, that is, the transmission conductor Y_3, Y_7, ..., Y_{59} or Y_{63}, is connected to an output terminal of a corresponding one of the periodic signal production sections 24 through a switch 22a as illustrated in FIG. 5.

[0055] Then, the periodic signals output from the periodic signal production sections 24 of the multi-frequency signal supplying circuit 21 and having frequencies different from each other are supplied at the same time to 16 transmission conductors 14 selected by the switches 22a of the transmission blocks 25. In this state, position detection of a pointer is carried out for a predetermined period of time. After the predetermined period of time passes, the switches 22a change over to be connected to adjacent ones of the transmission conductors 14 positioned in the direction in which the index n decreases, that is, to the transmission conductors Y_2, Y_6, ..., Y_{58} and Y_{62}. Then, frequency signals output from the periodic signal production sections 24 of the multi-frequency signal supplying circuit 21 and having different frequencies are supplied at the same time to the 16 transmission conductors 14 after the changeover to carry out position detection. This series of operations is repeated to carry out position detection of at least one pointer.

[0056] After those transmission conductors 14, which have the lowest indexes in the individual transmission blocks 25, that is, the transmission conductors Y_0, Y_4, ..., Y_{56} and Y_{60}, are selected by the switches 22a to carry out position detection of the pointer, those transmission conductors 14 having the highest indexes in the individual transmission blocks 25 are again selected by the switches 22a, and the series of operations described above are repeated in the individual groups. At this time, those transmission conductors 14, which are not selected by the switches 22a are preferably connected to an arbitrary reference potential or the ground potential. Where the transmission conductors, which are not selected by the switches 22a, are connected to an arbitrary reference potential or the ground potential such that noise, which may otherwise appear in those non-selected transmission conductors, can be minimized. Consequently, the noise resisting property can be improved. The procedure of the changeover (switching) operation of the transmission conductors 14 is not limited to the example described above with reference to FIG. 6. Modification is hereinafter described in detail.

[0057] As described above, in the transmission section 20, the plural transmission conductors 14 are divided into a plurality of groups, each including a predetermined number M (M is an integer equal to or greater than 2 ($M \geq 2$); in the example of FIG. 5, M = 4) of conductors. The supply signals, that is, periodic signals of different frequencies produced by the multi-frequency signal supplying circuit 21 are supplied to predetermined transmission conductors 14, which form the groups, and are successively changed over to be supplied to adjacent conductors in the individual groups. Since the transmission section 20 is configured in a manner described above, periodic signals for position detection can be supplied at the same time to a plurality of transmission conductors 14. Because, in the example described, 16 different frequencies are utilized at the same time, the time required for transmission of a signal for position detection can be reduced to 1/16 of that according to the prior art.

[0058] In this embodiment, where the frequency increases from f_0 toward f_{15}, if a comparatively low frequency (for example, f_0) is supplied to a transmission conductor positioned at a comparatively remote position from the reception section 30 and a comparatively high frequency (for example, f_{15}) is supplied to a transmission conductor positioned at a comparatively near position to the reception section 30, a high reception sensitivity is obtained.

[0059] Referring back to FIG. 1, the reception section 30 includes a reception conductor selection circuit 31, an amplification circuit 32, an A/D (Analog to Digital) conversion circuit section 33, a signal detection circuit 34 and a position calculation circuit 35. The reception conductor selection circuit 31, amplification circuit 32, A/D conversion circuit 33, signal detection circuit 34 and position calculation circuit 35 are disposed in this order from the sensor section 10 side.

[0060] The reception conductor selection circuit 31 in the first embodiment includes a number of switches equal to the number of detection blocks of the reception conductor group 11, that is, 16 switches.

[0061] FIG. 7 shows a general configuration of the reception conductor selection circuit 31 and associated elements. Referring to FIG. 7, the reception conductor selection circuit 31 includes a plurality of switches 31a. The switches 31a are provided in a one-by-one corresponding relationship with the detection blocks 36. Each of the switches 31a has eight terminals 31 b on the input side thereof, which are connected to corresponding ones of the reception conductors 12. Each of the switches 31a has a terminal 31c on the output side thereof, which is connected to an input terminal of a corresponding one of I/V conversion circuits 32a hereinafter described. Further, each of the switches 3 1a changes over between the reception conductors 12, which is to be connected to the corresponding I/V conversion circuit 32a. Outputs of the I/V conversion circuits 32a are output to a changeover switch 32d.

[0062] The changeover switch 32d successively changes over between the I/V conversion circuits 32a, which is to be connected to the A/D conversion circuit 33 after every predetermined interval of time to output voltage signals time-divisionally to the A/D conversion circuit 33. Where the configuration just described is used, it is necessary to provide only one system of an A/D conversion circuit 33 and a circuit group (synchronous detection circuit 37 and so forth), which is disposed at a succeeding stage to the A/D conversion circuit 33 in the reception section 30. Therefore, the circuit configuration of the reception section 30 is simple. The changeover switch 32d may be provided either in the amplification circuit 32 or in the A/D conversion circuit 33.

[0063] FIG. 8 illustrates changeover (switching) operation of the reception conductors 12 by the switches 31a. Referring to FIG. 8, the changeover operation of each of the switches 31a is controlled by the control circuit 40. In this example, it is assumed that the switches 31a in the detection blocks 36 are first connected to those reception conductors 12 having the lowest indexes, that is, to the reception conductors X_0, X_8, ..., X_{112} and X_{120}, as seen in FIG. 7. In this state, position detection of a pointer is carried out at the same time by those reception conductors 12, which are currently selected, for a predetermined period of time to obtain output signals S_0, S_1, ..., S_{15} of the individual groups.

[0064] When the predetermined period of time elapses, the switches 31a change over the connection of the reception conductors 12 to adjacent ones of the reception conductors 12 which are positioned in the direction in which the index m increases, that is, to the reception conductors X_1, X_9, ..., X_{113} and X_{121}. Then, output signals output from the reception conductors X_1, X_9, ..., X_{113} and X_{121} connected to the switches 31a after the changeover, that is, output signals S_0, S_1, ..., S_{15} of the individual groups, are obtained. Thereafter, the switches 31a repeat this sequence of operations to carry out position detection of the pointer.

[0065] Then, the switches 31a are connected to the reception conductors 12 having the highest indexes in the individual detection blocks 36, that is, to the reception conductors X_7, X_{15}, ..., X_{119} and X_{127}, and position detection of a pointer is carried out at the same time by the reception conductors 12. Thereafter, the switches 31a are again connected to the reception conductors 12 having the lowest indexes in the individual detection blocks 36, and the operations described above are repeated in the individual blocks. At this time, those reception conductors 12 which are not selected by the switches 3 1 a are preferably connected to an arbitrary reference potential or the ground potential. Where the reception conductors, which are not selected by the switches 31a, are connected to an arbitrary reference potential or the ground potential, noise, which may otherwise appear in the non-selected reception conductors, can be minimized. Consequently, the noise resisting property can be improved. The changeover (switching) operation of the reception conductors 12 is not limited to the example described above with reference to FIG. 8. Modification is hereinafter described in detail.

[0066] As described above, in the reception section 30, the reception conductors 12 are divided into a plurality of groups, each including a plurality of conductors. Then, at least one conductor which forms each group is selected, and the conductor to be selected is successively changed over among the conductors which form each group. In the configuration just described, multiple output signals for position detection can be obtained at the same time from the reception conductor group 11. Since the reception conductor group 11 is divided into 16 groups, the time required for reception of a signal for position detection can be reduced to 1/16 of that of the prior art.

[0067] The amplification circuit 32 acquires current signals output from the reception conductors 12, converts the current signals into voltage signals, and amplifies the voltage signals. Referring to FIG. 7, the amplification circuit 32 includes a number of I/V conversion circuits 32a equal to the number of detection groups of the reception conductor group 11, that is, 16 I/V conversion circuits 32a. The amplification circuit 32 also includes a changeover circuit 32d. One I/V conversion circuit 32a is connected to each of the detection blocks 36. In the present embodiment, each of the I/V conversion circuits 32a includes an amplifier 32b in the form of an operational amplifier having one input and one output, and a capacitor 32c connected to the amplifier 32b. A resistance element, a transistor, or the like, may be connected in parallel to the capacitor 32c in order to adjust the dc bias (omitted in FIG. 7).

[0068] The A/D conversion circuit 33 is connected to the amplification circuit 32 and converts an analog signal output from the amplification circuit 32 into a digital signal. An A/D converter known in the art may be used for the A/D conversion circuit 33.

[0069] Referring back to FIG. 1, the signal detection circuit 34 is connected to the A/D conversion circuit 33 and detects, from within an output signal from the A/D conversion circuit 33, a signal of an object frequency from a plurality of signals of different frequencies produced by the multi-frequency signal supplying circuit 21. More particularly, the signal detection circuit 34 determines a cross point and the level of the detection signal at the cross point. Then, the signal detection circuit 34 connects the levels of such detection signals between adjacent ones of the cross points and calculates a level curved surface of a mountain shape which exhibits an apex or peak at the cross point [X_m, Y_n], at which the pointer touches. Then, the signal detection circuit 34 outputs the level curved surface as bit map data to the position calculation circuit 35.

[0070] Referring to FIG. 9, the signal detection circuit 34 includes a signal detection section 34a having a number of synchronous detection circuits 37 equal to the number of the periodic signals, that is, 16 synchronous detection circuits 37, corresponding to the periodic signal production sections 24. The signal detection section 34a is connected at an input terminal thereof to an output terminal of the A/D conversion circuit 33. In the example of FIG. 7, the changeover switch 32d, which functions as a circuit for time-divisional selection, is provided on the output side of the I/V conversion circuit 32a. However, the changeover switch 32d may be replaced by a number of A/D conversion circuits equal to the number of the detection blocks 36.

[0071] FIG. 9 illustrates a connection relationship of the I/V conversion circuit 32a, which forms the amplification circuit 32, the A/D conversion circuit 33, and the signal detection sections 34a, which form the signal detection circuit 34, and an internal configuration of the signal detection section 34a. Referring to FIG. 9, an I/V conversion circuit 32a, an A/D conversion circuit 33 and a signal detection section 34a are connected in series in this order from the reception conductors 12 side.

[0072] A current signal output from a reception conductor 12 is converted into a voltage signal and amplified by the I/V conversion circuit 32a. The amplified signal is input to the A/D conversion circuit 33, where it is converted into a digital signal. The digital signal is input to the signal detection section 34a. Then, the signal detection section 34a detects, from within the digital signal, a signal of the same frequency as that of the periodic signal output from a corresponding one of the periodic signal production sections 24 in the multi-frequency signal supplying circuit 21.

[0073] The signal detection section 34a includes a plurality of synchronous detection circuits 37 and a plurality of registers 38 individually connected to the synchronous detection circuits 37. Each of the registers 38 is divided into four regions 38a to 38d. The registers 38 correspond to the transmission blocks 25 of the transmission conductor selection circuit 22, and the regions 38a to 38d in each of the registers 38 correspond to transmission conductors in a corresponding one of the transmission blocks 25. For example, data obtained by dividing output signals from the reception conductors 12 corresponding to periodic signals supplied to the transmission conductors Y_{63} to Y_{60} by one of the synchronous detection circuits 37 is stored into the regions 38a to 38d of the register 38 connected to the synchronous detection circuit 37. Instead of dividing each register 38 into four regions 38a to 38d as in the example described above, four independent registers may be provided for one synchronous detection circuit.

[0074] Each of the synchronous detection circuits 37 detects a signal of an object frequency from within the signal input thereto. The number of synchronous detection circuits 37 provided is equal to the number of the periodic signals, that is, 16, and the synchronous detection circuits 37 are connected in parallel to each other. Which one of the frequencies each of the synchronous detection circuits 37 should detect is controlled in an interlocking relationship with production of the periodic signal of the multi-frequency signal supplying circuit 21 and changeover (switching) of the transmission conductors 14 by the transmission conductor selection circuit 22 based on the timing signals inputting from the control circuit 40. In the example of FIG. 9, the synchronous detection circuits 37 are represented by indexes j from "0" to "15" in order beginning with that of the synchronous detection circuits 37 that is positioned remote from the A/D conversion circuit 33. In the following description, a synchronous detection circuit 37 corresponding to the index j is referred to as DCT_j. The synchronous detection circuits 37 at the first to 16th stages (DCT_0 to DCT_{15}) are connected at an input terminal thereof to the output terminal of the A/D conversion circuit 33. DCT means "discrete cosine transform."

[0075] FIG. 10 shows a general configuration of the synchronous detection circuit 37. Referring to FIG. 10, the synchronous detection circuit 37 includes, as principal components thereof, an input terminal 370, a signal source 371 for generating a frequency signal of a frequency f_k that is the object of detection, a multiplier 373 and an integrator 374. If a detection signal or an output signal is input from a reception conductor 12 to the synchronous detection circuit 37 through the A/D conversion circuit 33, it is supplied to the multiplier 373 of the synchronous detection circuit 37 through the input terminal 370. A periodic signal having a frequency f_k is input from the signal source 371 to the multiplier 373, and the detection signal and the periodic signal of the frequency f_k are multiplied to detect an object signal. Then, the detection signal is input to the integrator 374, where it is temporally integrated and output.

[0076] Where the frequency f_k of the periodic signal to be generated by the signal source 371 is set in this manner, a signal or signal component of the object frequency can be detected. A noise signal has a characteristic that, if an output for a fixed period of time is integrated, components having frequencies different from the frequency f_k are suppressed significantly. Therefore, if a signal component and noise components included in an output signal are integrated for a fixed period of time using the integrator 374, the signal component is amplified while the noise components cancel each other and are compressed.

[0077] If a $\pi/2$ phase shifter is used to shift the phase of the detection signal by $\pi/2$ to carry out detection, it is possible to detect a frequency signal of the frequency f_k having a phase displaced by $\pi/2$ from the signal component included in the detection signal. In other words, a DFT (Discrete Fourier Transform) configuration may be used, and this configuration may be preferable in a pointer detection apparatus that uses an electrostatic pen, in that a detectable phase range is expanded.

[0078] Referring back to FIG. 9, the number of registers 38 is equal to the number of the transmission conductors 14 (Y_0 to Y_{63}) similarly to the synchronous detection circuits 37, and the registers 38 are individually connected to the synchronous detection circuits 37 (DCT_0 to DCT_{15}). The registers 38 (regions 38a to 38d) retain signals detected by the corresponding synchronous detection circuits 37, and the signals retained in the registers 38 are read out to the position calculation circuit 35 based on timing signals from the control circuit 40.

[0079] Referring back to FIG. 1, the position calculation circuit 35 detects, from signals sent from the register 38 (regions 38a to 38d) of the synchronous detection circuits 37, a reception conductor 12, from which a signal which exhibits a dropped signal level is output, and a frequency of the signal. Then, the position calculation circuit 35 calculates the position of the pointer based on the index m (0 to 127) of the reception conductor 12 specified from the signal read out from the register 38 and the index n (0 to 63) of the transmission conductor 14 from which the corresponding periodic signal is supplied. The series of operations by the synchronous detection circuit 37 described above are carried out for the entire reception conductor group 11 in an interlocking relationship. A periodic signal is produced by the multi-frequency signal supplying circuit 21 and changeover of the transmission conductor 14 is carried out by the transmission conductor selection circuit 22. The position calculation circuit 35 outputs not only the position (coordinate) of a cross point, at which a pointer is placed, but also information of the surface area of the sensor section 10 over which the pointer is placed, and the pressure applied to the sensor section 10 by the pointer.

[Principle of Position Detection]

[0080] Now, the principle of position detection of a pointer by the pointer detection apparatus of the present embodiment will be described. As described above, the detection system of the present embodiment is an electrostatic coupling system of the cross point type. It detects the position of a pointer based on a variation of the electrostatic coupling state between the transmission conductors and the reception conductors of the sensor section.

[0081] An electrostatic coupling state between a transmission conductor 14 and a reception conductor 12 varies depending upon whether a pointer exists on the sensor section 10. FIG. 11A illustrates an electrostatic coupling state between a transmission conductor 14 and a reception conductor 12 where no pointer exists on the sensor section 10, and FIG. 11B illustrates an electrostatic coupling state between the transmission conductor 14 and the reception conductor 12 where a pointer exists on the sensor section 10.

[0082] If a pointer does not exist on the sensor section 10, as seen in FIG. 11A, the transmission conductor 14 and the reception conductor 12 are capacitively coupled to each other through the spacer 16, and an electric field emerging from the transmission conductor 14 converges to the reception conductor 12. As a result, current of a predetermined value flows between the transmission conductor 14 and the reception conductor 12.

[0083] However, if a finger 19 as a pointer exists on the sensor section 10, as seen in FIG. 11B, the reception conductor

12 is capacitively coupled not only to the transmission conductor 14 but also to the ground through the finger 19. In the state just described, part of an electric field emerging from the transmission conductor 14 converges to the finger 19 and part of current flowing between the transmission conductor 14 and the reception conductor 12 flows to the ground through the finger 19. As a result, the value of current flowing into the reception conductor 12 decreases. In the electrostatic coupling system, a variation of the value of current output from the reception conductor 12 is detected by the reception section 30 to detect the position of the pointer.

[0084] A position detection where a finger 19 is placed on a plurality of cross points of the sensor section 10 at the same time will now be described with reference to FIGS. 12A to 12D.

[0085] FIG. 12A shows the pointer detection apparatus 100 where a finger 19 is placed at a point (grid) of a certain transmission conductor and a certain reception conductor of the sensor section 10. Here, as an example, attention is directed to cross points between the transmission conductor Y_6 and the reception conductor X_4 and between the transmission conductor Y_6 and the reception conductor X_{122}. FIG. 12B illustrates output signals of the reception conductor X_4 and the reception conductor X_{122} on the transmission conductor Y_6. FIG. 12C illustrates a detection waveform of an output signal of the reception conductor X_7 on the transmission conductor Y_{58}. FIG. 12D illustrates a detection waveform of an output signal from the reception conductor X_7 on the transmission conductor Y_2.

[0086] As described above, if a finger 19 does not exist on the sensor section 10, output current from the reception conductor 12 has a predetermined value. However, if a finger 19 is placed in proximity to the cross points between the transmission conductor Y_6 and the reception conductor X_4 and between the transmission conductor Y_6 and the reception conductor X_{122}, the electrostatic coupling state between the transmission conductor Y_6 and the reception conductor X_4, and between the transmission conductor Y_6 and the reception conductor X_{122} varies as described above with reference to FIGS. 11A and 11B. Consequently, the current flowing into the reception conductors X_4 and X_{122} at the cross points varies. Thereupon, the frequency f_1 of the current output from the reception conductor X_4 and the reception conductor X_{122} corresponds to the frequency f_1 of the periodic signal supplied to the transmission conductor Y_6.

[0087] The reception conductor X_4 has a detection order number of five in the detection block 36 (refer to FIG. 7), and the reception conductor X_{122} has a detection order number of three in the detection block 36 (refer to FIG. 7). Therefore, the synchronous detection circuit 37 detects the output signal of the reception conductor X_{122} with the same frequency as that of the periodic signal supplied to the transmission conductor 14 at a certain clock time, and then detects the output signal of the reception conductor X_4 with the same frequency after an interval of two clocks. The output signals of the reception conductor X_4 and the reception conductor X_{122} have a decreased level and the position of the finger can be detected in this manner.

[0088] If multiple fingers 19 are placed on a plurality of cross points along one of the reception conductors 12 of the sensor section 10, the positions can be detected similarly. A detection operation where multiple fingers are placed on a plurality of cross points along the same reception conductor 12 is described below.

[0089] It is assumed that fingers 19 are placed on the transmission conductor Y_{58} and Y_2 along the reception conductor X_7 of the sensor section 10, as seen in FIG. 12A. A periodic signal of a frequency f_{14} is supplied to the transmission conductor Y_{58}, while another synchronizing signal of the frequency f_0 is supplied to the transmission conductor Y_2. Here, the transmission conductor Y_{58} has a supplying order number of three in the corresponding transmission block 25, as shown in FIG. 5, and the transmission conductor Y_2 also has a supplying order number of three in the corresponding transmission block 25, as shown in FIG. 5. Therefore, an output signal of the reception conductor X_7 is detected simultaneously, with the frequencies f_{14} and f_0 of the periodic signals supplied to the transmission conductors 14, by the DCTs DCT_{14} and DCT_0 of the synchronous detection circuits 37. In this manner, it is detected that the levels of the output signals of the reception conductor X_7 with respect to the transmission conductor Y_{58} and the reception conductor X_7 with respect to the transmission conductor Y_2 decrease as seen in FIGS. 12C and 12D, respectively, and thus the positions of the fingers can be specified.

[0090] In the cross point type electrostatic coupling system configured in a manner described above, the position of a finger 19 can be specified by detecting the index n (0 to 63) of the transmission conductor 14, to which a periodic signal is applied, and the index m (0 to 127) of the reception conductor 12, on which reduction of the output signal is detected. On the other hand, in the projection type electrostatic coupling system, where fingers may overlap with each other, it is impossible to specify the positions of the fingers.

[0091] It is to be noted that, when the supplying order of periodic signals to the transmission conductors 14 differs depending upon the place of a cross point (transmission conductor), the order in which a variation of current flowing to the cross points can be detected through the same reception conductor 12 becomes different. In other words, the timing at which variations of current flowing to the cross points are detected is not always the same, as in the case just described above wherein the fingers 19 are placed on the transmission conductors Y_{58} and Y_2 along the reception conductor X_7.

[0092] Where a finger 19 is placed over a plurality of successive cross points of the sensor section 10, the position of the finger 19 can be detected in accordance with a principle similar to that described above. In this instance, the positions of the cross points to be detected appear successively, and a region in which the finger 19 is placed over can be detected. In other words, the shape of the finger 19 placed on the sensor section 10 can be estimated. Therefore, in the present embodiment, not only the position of a pointer disposed on the sensor section 10, but also the shape of the pointer placed at the sensor section 10 can be estimated. For example, where the palm is placed on the sensor section 10, not only the position of the hand, but also the shape of the palm of the hand can be estimated.

[Operation of the Pointer Detection Apparatus]

[0093] An operation of the pointer detection apparatus 100 of the present embodiment will now be described with reference to the drawings. FIG. 13 illustrates a detection procedure of a pointer by the pointer detection apparatus 100 of the present embodiment.

[0094] First, each of the periodic signal production sections 24 in the multi-frequency signal supplying circuit 21 sets a periodic signal of a frequency allocated thereto by the control circuit 40 at step S 1.

[0095] Then, the reception conductor selection circuit 31 of the reception section 30 uses the switches 31a to select a predetermined reception conductor 12 in each of the detection blocks 36, and connects the selected reception conductors 12 to the corresponding I/V conversion circuits 32a at step S2.

[0096] Then, the transmission conductor selection circuit 22 selects one of the transmission conductors 14, to which a periodic signal is to be supplied in each of the transmission blocks 25, at step S3. The multi-frequency signal supplying circuit 21 supplies, to the predetermined transmission conductors 14 selected in the transmission blocks 25, corresponding periodic signals at the same time at step S4. The predetermined reception conductors 12 in the detection blocks 36 to be selected upon starting the position detection process are preferably selected in advance before the periodic signals are supplied to the transmission conductor group 13.

[0097] Then, the reception section 30 detects output current from the predetermined reception conductors 12 selected at step S2 at the same time at step S5. In particular, the amplification circuit 32 first converts the output current from the selected predetermined reception conductors 12, that is, from the 16 reception conductors 12, into voltages, amplifies the voltages, and outputs the amplified signals to the A/D conversion circuit 33. At this time, the output current is converted into voltages by the I/V conversion circuits 32a connected to the reception conductors 12 and amplified. Thereafter, the A/D conversion circuit 33 A/D converts the input voltage signals and outputs the resulting digital signals to the signal detection circuit 34.

[0098] Then, the signal detection circuit 34 synchronously detects the different frequency components from the digital signals input thereto at step S6. In particular, the signal detection sections 34a connected to the A/D conversion circuit 33 detect signals of the same frequencies as the frequencies supplied to the transmission conductors 14 from the signals detected through the corresponding reception conductors 12. Then, the signal detection circuit 34 stores the signals calculated with regard to the predetermined reception conductors 12 into the registers 38 (regions 38a to 38d) at step S7.

[0099] Then, the control circuit 40 decides at step S8 whether or not the position detection with regard to all transmission conductors 14 ends on the reception conductors 12 selected at step S2. If the position detection with regard to all transmission conductors 14 does not end on the selected reception conductors 12, that is, if the result of the decision at step S8 is NO, then the processing returns to step S3, at which the switches 22a in the transmission blocks 25 in the transmission conductor selection circuit 22 are changed over to select the transmission conductors 14 different from those in the preceding operation cycle. Then, multi-frequency signals are supplied simultaneously from the multi-frequency signal supplying circuit 21 to the selected transmission conductors 14. Thereafter, the processes at steps S3 to S7 are repeated until the position detection with regard to all transmission conductors 14 ends on the selected reception conductors 12. If the position detection with regard to all transmission conductors 14 ends on the selected reception conductors 12, the signals at all cross points on the reception conductors 12 stored in the registers 38 are read out into the position calculation circuit 35.

[0100] Referring to FIGS. 1, 5 and 7, for example, when the reception conductors X_0, X_8, ..., and X_{120} are selected, periodic signals are supplied to the transmission conductors Y_3, Y_7, ..., and Y_{63} to carry out position detection. Then, at a next clock signal, while the reception conductors remain selected, periodic signals are supplied this time to the transmission conductors Y_2, Y_6, ..., and Y_{62} to carry out position detection. This process is repeated until periodic signals are supplied to the transmission conductors Y_0, Y_4, ..., and Y_{60} to carry out position detection. At this time, a full cycle of the changeover (switching) of transmission conductors in each group is completed, and the position detection of all transmission conductors 14 regarding the reception conductors X_0, X_8, ..., and X_{120} is completed. This is a state when the result of the decision at step S8 is YES. If the detection of all transmission conductors with regard to the selected reception conductors is ended in this manner, the processing advances to step S9.

[0101] When the position detection with regard to all transmission conductors 14 ends on the reception conductors 12 selected at step S4, that is, if the result of the decision at step S8 is YES, then the control circuit 40 decides at step S9 whether or not the position detection with regard to all reception conductors 12 is completed. If the position detection with regard to all reception conductors 12 is not completed, (the result of the decision at step S9 is NO), the processing returns to step S2, at which the switches 31a of the detection blocks 36 in the reception conductor selection circuit 31 are changed over to select the reception conductors 12 different from those in the preceding operation cycle. Further, concurrently with the changeover on the reception side, the switches 22a of the transmission blocks 25 in the transmission conductor selection circuit 22 are changed over to select those transmission conductors 14 which are different from those in the preceding cycle, that is, the same as those selected first at step S3. Then, to the selected transmission conductors 14, multi-frequency signals are supplied at the same time from the multi-frequency signal supplying circuit 21. In this manner, the reception conductors 12 and the transmission conductors 14 are changed over to continue the position detection. Thereafter, the processes at steps S2 to S8 are repeated until the position detection with regard to the transmission conductors 14 is completed on all reception conductors 12.

[0102] Referring to FIGS. 1, 5 and 7, for example, when the reception conductors X_0, X_8, ..., and X_{120} remain selected, the transmission conductor 14 to be selected in each group is rotated such that position detection of all transmission conductors in each group is carried out with regard to the reception conductors X_0, X_8, ..., and X_{120}. Then, the reception conductors 12 to be selected are changed over to the reception conductors X_1, X_9, ..., and X_{121}, and the transmission conductor 14 to be selected in each group is rotated in a manner described above. The sequence of processes described is repeated to successively change over the reception conductors 12 to be selected. If at the end of the rotation, the position detection with regard to all transmission conductors is completed with respect to the reception conductors X_7, X_{15}, ..., and X_{127}, the processing advances to step S10, but if the position detection is not completed, the processing returns to step S2.

[0103] The position calculation circuit 35 detects, from the signals at the cross points of the reception conductors 12 input from the synchronous detection circuit 37, a reception conductor 12, which outputs a signal having a reduced signal level and the frequency of the signal. At step S10, the position calculation circuit 35 calculates the position of the pointer based on the index m (0 to 127) of the reception conductor 12 specified from the signal level and the index n (0 to 63) of the transmission conductor 14 from which the periodic signal is supplied. In the present embodiment, position detection of the pointer disposed on the sensor section 10 is carried out in this manner.

[0104] As described above, in the first embodiment, signals having different frequencies are supplied simultaneously or multiple-transmitted to predetermined ones of the transmission conductors 14 in the individual groups, and the position of the pointer is detected at the same time through a predetermined plural number of reception conductors 12. In other words, a position detection process is carried out at the same time for a plurality of cross points between the transmission conductors 14 and the reception conductors 12. Therefore, with the present embodiment, the time required for position detection for a plurality of cross points can be reduced and higher speed position detection becomes possible.

[0105] More particularly, in the first embodiment, the transmission conductor group 13 and the reception conductor group 11 are each divided into 16 groups and the groups are processed in parallel to each other. Therefore, in the present embodiment, the detection time can be reduced, for example, to $1/(16 \times 16)$ in comparison with the detection time where a detection process is carried out successively for all cross points as in the prior art. The number of groups is not limited to the specific number mentioned above, and an effect of reduction of the detection time can be obtained even if only one of the transmission conductor group 13 and the reception conductor group 11 is divided into groups.

[0106] Further, in the first embodiment described above, after detection ends for all transmission conductors on one reception conductor, the processing-object reception conductor is changed over to a next reception conductor to continue the position detection. However, the position detection is not limited to this configuration. For example, the processing-object reception conductor may be changed over to another reception conductor to continue position detection before the detection with regard to all transmission conditions on one reception conductor is completed. It is only necessary for the position detection to be carried out in the end at all cross points of the sensor section 10.

[Modification 1]

[0107] In the first embodiment described above, the sensor section 10 is configured such that the reception conductors 12 and the transmission conductors 14 between which the spacer 16 is interposed are formed on one of the surfaces of the first glass substrate 15. However, the present invention is not limited to such arrangement. For example, the reception conductors and the transmission conductors may be formed on the opposite faces of one glass substrate. FIG. 14 shows an example of such configuration.

[0108] In particular, FIG. 14 shows a schematic cross section of a sensor section according to modification 1.

[0109] Referring to FIG. 14, the sensor section 50 according to modification 1 includes a glass substrate 51, a plurality of transmission conductors 52 formed on one of surfaces of the glass substrate 51, on the lower face of the glass substrate 51 in FIG. 14, and a first protective layer 53 formed on the transmission conductors 52. The sensor section 50 further includes a plurality of reception conductors 54 formed on the other surface of the glass substrate 51, on the upper surface of the glass substrate 51 in FIG. 14, a second protective layer 55 formed on the reception conductors 54, and a protective sheet 56 formed on the second protective layer 55. The detection surface for a pointer in the present example is a surface of the sensor section 50 on the protective sheet 56 side.

[0110] In modification 1, the glass substrate 51, transmission conductors 52 and reception conductors 54 are formed from materials similar to those used in the first embodiment described above. Further, in modification 1, the glass substrate 51 may be replaced by a sheet-like or film-like substrate formed from a synthetic resin material similarly as in the first embodiment. Further, the first protective layer 53 and the second protective layer 55 can be formed, for example, from a SiO_2 film or a synthetic resin film, and the protective sheet 56 may be formed using a sheet member made of, for example, a synthetic resin material.

[0111] Since the sensor section 50 of modification 1 can reduce the number of glass substrates in comparison with the sensor section 10 of the first embodiment described above with reference to FIG. 2, the thickness of the sensor section 50 can be further reduced. Further, in the sensor section 50 of modification 1, since the number of glass substrates can be reduced, a less expensive sensor section can be formed.

[Modification 2]

[0112] FIGS. 15A and 15B illustrate an example of a configuration of a sensor section where transmission conductors and reception conductors are formed on the surface on one side of a glass substrate, as modification 2. In particular, FIG. 15A shows a cross section of the sensor section of modification 2 at a cross point, and FIG. 15B shows a perspective view of the sensor section of modification 2.

[0113] Referring to FIGS. 15A and 15B, the sensor section 60 shown includes a glass substrate 61, metal sections 62 having conductivity and formed in a predetermined pattern on one of the surfaces of the glass substrate 61" insulating sections 63 formed on the metal sections 62, a plurality of transmission conductors 64, and a plurality of reception conductors 65. Although a protective layer and a protective sheet are provided, they are omitted in FIGS. 15A and 15B.

[0114] The metal sections 62 are substantially linear metal members formed, for example, by drawing a metal material in a direction perpendicular to the direction in which the reception conductors 65 extend. The insulating sections 63 are formed so as to cover over part of the metal sections 62. Further, the transmission conductors 64 are provided at the opposite ends in the drawing direction of the metal sections 62 and are electrically connected to each other by the metal sections 62. The reception conductors 65 are formed so as to stretch over the insulating sections 63, such that the reception conductors 65 are electrically isolated from the metal sections 62 and transmission conductors 64.

[0115] Although in FIGS. 15A and 15B, the transmission conductors 64 are formed in such a manner as to cover over part of the upper surface of the metal sections 62 and the insulating sections 63, the present modification is not limited to the form described. Since the object of the provision of the metal sections 62 is achieved as long as the transmission conductors 64 provided at the opposite ends in the extension direction of the metal sections 62 are electrically connected to each other by the metal sections 62, there is no need, for example, for the transmission conductors 64 to cover over the upper surface of the metal sections 62. Similarly, although, in FIGS. 15A and 15B, the transmission conductors 64 are shown covering over part of the upper surface of the insulating sections 63, the covering state is not limited to this arrangement. It is only necessary for the reception conductors 65 to be electrically isolated from the transmission conductors 64 and metal sections 62.

[0116] Further, in the example of FIGS. 15A and 15B, the detection surface for a pointer may be the surface of the glass substrate 61 on which the conductors are formed or the face of the glass substrate 61 opposite to the face on which the conductors are formed.

[0117] In modification 2, the reception conductors 65 are formed from a linear conductor similar to the first embodiment described above. Meanwhile, the transmission conductors 64 are formed so as to be connected to the metal sections 62 through openings in the insulating sections 63. In particular, the transmission conductors 64, to which periodic signals are supplied, are disposed three-dimensionally such that they pass below the reception conductors 65 with the insulating sections 63 sandwiched therebetween.

[0118] Further, in modification 2, the glass substrate 61, transmission conductors 64 and reception conductors 65 are formed from materials similar to those which are used in the first embodiment described above. In the present example, the glass substrate 61 may be replaced with a sheet-like or film-like substrate formed from a synthetic resin material similarly as in the first embodiment.

[0119] The metal sections 62 can be formed from a metal material having a high conductivity such as, for example, Mo (molybdenum) or Al (aluminum). Since the dimension of the connecting portions between the metal sections 62 and the transmission conductors 64 is very small, in order to reduce the resistance at the connecting portions, it is preferable to use a metal material having a high conductivity for the metal sections 62. Further, the insulating sections 63 may be formed, for example, from resist.

[0120] With the sensor section 60 of modification 2, since the number of glass substrates can be reduced in comparison with the sensor section 10 of the first embodiment described above with reference to FIG. 2, the thickness of the sensor section 60 can be reduced. Further, in the sensor section 60 of the present example, since the number of glass substrates can be reduced, a less expensive sensor section can be provided. Further, cost reduction occurs also because wiring lines of the transmission conductors and the reception conductors can be formed in the same layer.

[0121] Furthermore, the sensor section 60 of modification 2 can achieve the following advantage in comparison with the sensor section 50 of modification 1. In particular, where the face of the glass substrate 61 on the side opposite to the face, on which the conductors are formed, is used as the detection surface for a pointer in the sensor section 60 of modification 2, the glass substrate 61 exists between the pointer and the conductors. In this instance, the distance between the pointer and the conductors increases in comparison with that in the sensor section 50 of modification 1, and any effect of noise from the pointer decreases.

[Modification 3]

[0122] In the first embodiment and modifications 1 and 2 described above, the transmission conductors and the reception conductors can be individually formed from a linear conductor of a fixed width extending in a predetermined direction. However, the shape of the transmission conductors and the reception conductors in the present invention is not limited to a linear shape extending in a predetermined direction. Another example of a configuration of the transmission conductors is described below as modification 3.

[0123] FIG. 16A shows, in an enlarged scale, cross points between transmission conductors and reception conductors in a sensor section of modification 3, and FIG. 16B shows a land conductor portion 73A in an enlarged scale.

[0124] Referring to FIGS. 16A and 16B, in the sensor section 70A of modification 3 shown, the reception conductors 74 are formed from a linear conductor of a fixed width as seen in FIG. 16A. However, the transmission conductors 71A are formed from a linear conductor portion 72 and land conductor portions 73A having a width greater than that of the linear conductor portion 72 and made of ITO or the like.

[0125] Referring to FIG. 16B, each land conductor portion 73A includes first and second land portions 73b and 73c formed in a substantially same shape and a substantially linear connecting portion 73d for electrically connecting the first and second land portions 73b and 73c to each other. The first and second land portions 73b and 73c are formed in a substantially triangular shape having an apex 73a, at which the land conductor portion 73A is connected to the linear conductor portion 72. The first land portion 73b and the second land portion 73c are electrically connected to each other at bottom portions 73e thereof, opposite the apexes 73a, by the connecting portion 73d.

[0126] Where the transmission conductor 71A is formed in a shape described above, it is provided with an increased area in proximity to the cross point. As a result, when a pointer comes near the sensor section, an electric field emerging from the transmission conductor converges by an increasing amount to the pointer, and therefore, the detection sensitivity is improved.

[0127] Further, the land conductor portion 73A is shaped in a substantially H shape such that the first land portion 73b and the second land portion 73c are connected to each other by the connecting portion 73d to provide recesses 73f therebetween. Thus, if the pointer detection apparatus, to which the present invention is applied, and another pointer detection apparatus, which adopts an electromagnetic resonance system, are placed one on the other to form an inputting apparatus wherein a region for detecting a pointer is formed commonly between the two pointer detection apparatus, eddy current in the transmission conductors resulting from an electric field generated from the position detection apparatus of the electromagnetic resonance system is suppressed. As a result, deterioration of the detection sensitivity of the pointer detection apparatus of the electromagnetic resonance type due to loss caused by the eddy current can be prevented.

[0128] FIG. 17 shows, in an enlarged scale, a cross point between a transmission conductor and a reception conductor in a sensor section of another example of modification 3.

[0129] Referring to FIG. 17, in the sensor section 70B of the present example, a transmission conductor 71 B includes a linear conductor portion 72 and a land conductor portion 73B modified from that in modification 3. The sensor section 70B is different from that of modification 3 in that, while the land conductor portion 73A in modification 3 has the first and second land portions 73b and 73c of a substantially triangular shape, the land conductor portion 73A in the present example has first and second land portions 73g and 73h having a substantially trapezoidal shape. In the present example, the land conductor portion 73B is electrically connected at smaller parallel sides 73i thereof, which correspond to the apexes 73a of the first and second land portions 73b and 73c in modification 3, to the linear conductor portion 72. The remaining part of the sensor section 70B is similar to that of the sensor section 70A described above with reference to FIG. 16, and the description of the common configuration is omitted to avoid redundancy.

[0130] Comparing the present land conductor portion 73B to the land conductor portion 73A in modification 3, since the land conductor portion 73B is shaped such that it has no apex portion 73a, that is, no sharp (acute) angle portion, the flow path of electric current is wider than that of the land conductor portion 73A. As a result, concentration of current upon the connecting portion between the land conductor portion 73B and the linear conductor portion 72 does not occur, and the current disperses. In particular, since current flows in a spread fashion between the smaller parallel sides 73i, which define the opposite ends of the land conductor portion 73B, the resistance value between the smaller parallel sides 73i does not increase. As a result, the electric conduction characteristic is further improved in comparison with that of the transmission conductors in modification 3 described above with reference to FIG. 16. Where the transmission conductors around the cross points of the sensor section are shaped in this manner, the electric conduction characteristic can be further improved. The shape of the smaller parallel side 73i preferably has no sharp (acute) angle portion and the smaller parallel side 73i may have, for example, a curved shape different from the shape described above and shown in FIG. 17. Further, while the sensor section 70B in the present example is configured such that the two recesses 73f are formed in the land conductor portions 73A and 73B, the number of such recesses is not limited to two, and four or more recesses may be provided.

[0131] The two examples of modification 3 shown in FIGS. 16 and 17 can be applied not only in the sensor section of the pointer detection apparatus of the cross point type electrostatic coupling system, but can be applied also in a sensor section of a pointer detection apparatus of the projected capacitive type or some other type. Further, while in modification 3 a unique shape of the land conductor portion of the transmission conductors is proposed, a similar shape may be used to form a land conductor portion on the reception conductors in proximity to the cross points.

[0132] Further, the land conductor portion can be applied to any of the sensor section 50 formed from two layers in modification 1 described above with reference to FIG. 14, and the sensor section 60 formed from one layer in modification 2 described above with reference to FIG. 15. Where the pointer detection apparatus is formed integrally with a display apparatus such as in a liquid crystal panel, in order to suppress the influence of electrostatic noise from the liquid crystal panel, the reception conductors are preferably disposed in a direction crossing the scanning direction of the liquid crystal panel.

[Modification 4]

[0133] A pointer detection apparatus in a cross point electrostatic coupling system has a region wherein a plurality of reception conductors and a plurality of transmission conductors cross each other and a conductor pattern exists, and another region wherein no conductor exists and no conductor pattern exists, if the sensor section is viewed from the surface of the pointer detection apparatus on which a pointer is to be operated, that is, from above the surface of the pointer detection apparatus. Although the conductors are formed from a transparent electrode film such as an ITO film, the transmission factor in the region in which the conductor pattern exists is lower than that in the region in which no conductor pattern exists. As a result, unevenness of the transmission factor appears on the sensor section. The user may feel uneasy with the unevenness of the transmission factor. Therefore, modification 4 is configured so as to eliminate such unevenness of the transmission factor on the sensor section.

[0134] FIG. 18 shows a general configuration of the sensor section of modification 4. The configuration of modification 4 is applied to the sensor section 50 of modification 1 described above with reference to FIG. 14. Referring to FIG. 18, in the sensor section 70C of modification 4, in a region in which none of transmission conductors 52 and reception conductors 54 exist, first transparent electrode films 333 and second transparent electrode films 334 made of the same material as the conductors are provided. The other part of the sensor section 70C has the same configuration as that of the sensor section 50 of modification 1 described above with reference to FIG. 14.

[0135] FIG. 19A shows a configuration of a transmission conductor 52 and a first transparent electrode film 333 formed on one surface, that is, on the lower surface, of a glass substrate of the sensor section 70C. The first transparent electrode film 333 of a rectangular shape is disposed on the surface of a glass substrate, on which the transmission conductor 52 is provided, between two transmission conductors 52 disposed in proximity to each other. The first transparent electrode film 333 has a dimension a little smaller than the dimension of the distance between the transmission conductors such that it does not contact with any of the transmission conductors 52, and is spaced away from the reception conductors 52 with some air gap left therebetween. The dimension of the first transparent electrode film 333 in the lengthwise dimension of the transmission conductors 52 is a little smaller than the dimension of the sum of the distance between the reception conductors 54 disposed in proximity to each other and the conductor width of one reception conductor 54. The first transparent electrode film 333 is disposed between the two reception conductors 54 positioned in proximity to each other, and is positioned such that both sides thereof extend to overlap approximately 1/2 of the conductor width of the reception conductors 54.

[0136] FIG. 19B shows a configuration of a reception conductor 54 and a second transparent electrode film 334 formed on the other surface, that is, on the upper surface, of the glass substrate of the sensor section 70C. In the present example, the second transparent electrode film 334 is disposed on the surface of the glass substrate on which the reception conductor 54 is disposed. Regarding the dimension of the second transparent electrode film 334, an approach similar to that used where the dimension of the first transparent electrode film 333 is defined can be applied. In particular, the second transparent electrode film 334 has a little smaller dimension than the dimension between the reception conductors so that it does not contact with the reception conductors 54, and is spaced away from the reception conductors 54 with some air gap left therebetween. Regarding the dimension of the second transparent electrode film 334 in the lengthwise dimension of the reception conductor 54, it is set such that the second transparent electrode film 334 partly overlaps with part of the transmission conductor 52 disposed in proximity to each other. The first transparent electrode film 333 and the second transparent electrode film 334 should be disposed such that, when the sensor section 70C is viewed from the surface side of the sensor section 70C on which a pointer is to be operated, that is, from the upper surface side, the superposing relationship of the transmission conductor 52, reception conductor 54, first transparent electrode film 333, and second transparent electrode film 334 is made as uniform as possible while the electric isolation from each other is maintained. Thus, unevenness of the transmission factor can be suppressed over the entire sensor section 70C and a uniform optical characteristic can be maintained.

[0137] If the conductors and the transparent electrode films formed on the surfaces of the glass substrate of the sensor section 70C are disposed as seen in FIGS. 19A and 19B, then when the sensor section 70C is viewed from above, the first transparent electrode films 333 and the second transparent electrode films 334 made of the same material as the conductors, are formed also in a region, in which the conductor pattern does not exist (as seen in FIG. 18). As a result, unevenness of the transmission factor on the sensor section 70C is suppressed.

[0138] The shape of the first transparent electrode film 333 and the second transparent electrode film 334 for suppressing unevenness of the transmission factor is not limited to a rectangular shape. It is only necessary that the superposing relationship between the conductor pattern formed from the transparent electrodes, the first transparent electrode films 333, and second transparent electrode films 334. when the sensor section 70C is viewed from above, be optically uniform. The shape of the first transparent electrode films 333 and the second transparent electrode films 334 is suitably set in relation to the shape of the conductor pattern formed from the transparent electrode films. For example, a plurality of transparent electrode films of a rectangular shape are disposed in a spaced relationship from each other by a predetermined distance and extend along a direction in which the transmission conductors or the reception conductors extend. However, the plural transparent electrode films may otherwise be formed as a single electrode film.

[Modification 5]

[0139] While in the first embodiment described above, both of the transmission conductors and the reception conductors are linear conductors and extend perpendicularly to each other, the preset invention is not limited to such arrangement. For example, at least one of the transmission conductors and the reception conductors may be formed from a curved conductor. An example is shown in FIG. 20.

[0140] FIG. 20 shows an arrangement pattern of a transmission conductor group 82 and a reception conductor group 81 of a sensor section 80 according to modification 5. In modification 5, the transmission conductor group 82 includes a plurality of transmission conductors 82a individually formed as rings having different diameters from each other. The ring-shaped transmission conductors 82a are disposed in a concentric relationship with each other such that the distances between adjacent ones of the transmission conductors 82a in a radius direction are equal to each other.

[0141] Meanwhile, the reception conductor group 81 includes a plurality of linear reception conductors 81a formed so as to extend radially from the center of the transmission conductor group 82. The reception conductors 81a are disposed in an equidistantly spaced relationship from each other in a circumferential direction of the concentric circles formed from the transmission conductor group 82. While in modification 5 shown in FIG. 20, the transmission conductors 82a are disposed in an equidistantly spaced relationship from each other, the distances between the transmission conductors 82a need not be equal to each other, but may be set to suitable distances in accordance with an application of the present invention.

[0142] The sensor section 80 in modification 5 is suitable for detection, for example, of rotational operation.

[Modification 6]

[0143] While in the first embodiment described above, a one-input one-output amplifier is used for the amplifier 32b in the amplification circuit 32 as seen in FIG. 7, the present invention is not limited to such configuration. For example, a differential amplifier may be used for the amplifier. An example is shown in FIGS. 21A and 21B. In FIGS. 21 A and 21B, elements like those in the first embodiment described above with reference to FIG. 7 are denoted by like reference characters and overlapping description of them is omitted herein to avoid redundancy.

[0144] In particular, FIG. 21A shows a general configuration of an amplifier according to modification 6, and FIG. 21B shows a general configuration of an amplification circuit and peripheral circuits where a differential amplifier is used.

[0145] Referring first to FIG. 21A, the differential amplifier 85 in modification 6 is a two-input one-output differential amplifier. In modification 6, a pair of adjacent ones of reception conductors 12 are connected one by one to the two input terminals of the differential amplifier 85. Further, in modification 6, the reception conductor group 11 includes 129 reception conductors 12. The reception conductor group 11 is divided into 16 detection blocks 36, each including 9 reception conductors 12. Each detection block 36 includes 9 reception conductors 12 which are positioned adjacent to each other, that is, which have consecutive indexes m. The ninth one of the reception conductors 12 which has the highest index m in each detection block 36 is used commonly by an adjacent detection block 36. In particular, in modification 6, the reception conductor group 11 is divided into detection blocks $\{X_0$ to $X_8\}$, $\{X_8$ to $X_{15}\}$, ..., $\{X_{114}$ to $X_{121}\}$ and $\{X_{121}$ to $X_{128}\}$.

[0146] Referring now to FIG. 21B, a reception conductor selection circuit 88 includes a plurality of pairs of switches

88a and 88b. One pair of switches 88a and 88b are provided for each one detection block 36. The paired switches 88a and 88b include nine common input terminals 31b. The common input terminals 31b are connected to corresponding ones of the reception conductors 12. Terminals 88c and 88d of the paired switches 88a and 88b on the output side are connected to input terminals of different I/V conversion circuits 32a. The one of the I/V conversion circuits 32a, which is connected to the output terminal of the switch 88a, is connected to the negated input terminal, which has the negative polarity (-), of a differential amplifier 85. The other I/V conversion circuit 32a, connected to the output terminal of the switch 88b, is connected to the non-negated input terminal, which has the positive polarity (+), of the differential amplifier 85. The paired switches 88a and 88b are structured such that those reception conductors 12, which are to be connected to the I/V conversion circuits 32a, are changed over at predetermined time intervals. In particular, if it is assumed that the switch 88a is connected to the reception conductor X_0 and the switch 88b is connected to the reception conductor X_1 first, the switches 88a and 88b are changed over after a predetermined time interval such that the switch 88a is connected to the reception conductor X_1 and the switch 88b is connected to the reception conductor X_2. Thereafter, the conductors to be connected are successively changed over at predetermined time intervals. Then, after the switch 88a is connected to the reception conductor X_7 and the switch 88b is connected to the reception conductor X_8, the switches 88a and 88b are changed over such that the switch 88a is again connected to the reception conductor X_0 and the switch 88b is again connected to the reception conductor X_1.

[0147] Where the differential amplifier 85 is used in the reception section, since noise included in outputs from the reception conductors 12 is canceled by the differential amplifiers 85, the noise resisting property can be improved.

[Modification 7]

[0148] While in modification 6 the number of reception conductors to be connected to a differential amplifier is two, the number of reception conductors to be connected to a differential amplifier may be further increased. An example is shown in FIG. 22.

[0149] FIG. 22 shows a general configuration of a differential amplifier according to modification 7.

[0150] Referring to FIG. 22, in the differential amplifier 86 in modification 7, the number of reception conductors 12 connected at the same time to the differential amplifier 86 is five. Those five reception conductors 12, which are positioned adjacent to each other, are used as the reception conductors 12 to be connected at the same time. In the example of FIG. 22, the five reception conductors 12 connected to the differential amplifier 86 shown are reception conductors X_{m-2} to X_{m+2}. In particular, the reception conductors X_{m-2} and X_{m-1} are connected to the negated input terminal of the differential amplifier 86, and the reception conductors X_{m+2} and X_{m+1} are connected to the non-negated input terminal of the differential amplifier 86. The central reception conductor X_m is connected to the terminal of a predetermined reference voltage level (e.g., ground) of the differential amplifier 86. If the differential amplifier 86 is of the single power supply type, the voltage level of the reception conductor X_m is set to a predetermined reference voltage level, but if the differential amplifier 86 is of the double power supply type, the voltage level of the reception conductor X_m is zero.

[0151] Where a configuration as just described is adopted, a plurality of outputs from different reception conductors 12 are input at the same time to the differential amplifier 86. As a result, since the level of the difference signal increases, the integration signal also increases, and the detection sensitivity can be improved. Further, since the number of reception conductors, whose output signals are to be input at the same time to the differential amplifier 86, increases, the range over which detection is possible is expanded. Further, since the differential amplifier 86 is used, the noise resisting property can be improved similar to modification 6.

[0152] In the example of FIG. 22, the reception conductor selection circuit 31 is not shown. In the succeeding drawings, only those elements that are necessary for description of the present invention are shown. This applies also to illustration of the switches 22a of the transmission conductor selection circuit 22.

[0153] The reason why the central reception conductor X_m to be connected to the differential amplifier 86 is set to the predetermined reference voltage level in modification 7 is as follows. In particular, as described above in connection with the first embodiment, in the electrostatic coupling system, current at a cross point near a pointer is shunted to the ground through the pointer, and the variation of the current at the cross point due to shunting is detected. However, if the pointer is not grounded sufficiently, then the shunting of current at the cross point becomes insufficient to be detected. In this instance, the current variation at the cross point becomes small, and the sensitivity in position detection decreases.

[0154] However, if the reception conductor X_m, which is positioned at the center of a plurality of reception conductors connected to the differential amplifier 86, is set to a reference voltage level or the zero voltage as in modification 7, even if the pointer is not grounded sufficiently, as long as the pointer is positioned in proximity to the reception conductor X_m, part of the current can be shunted through both the pointer and the reception conductor X_m. As a result, the decrease in the sensitivity described above can be minimized.

[Modification 8]

[0155] While in modifications 6 and 7 a differential amplifier is utilized to assure high detection sensitivity, it is also possible to inverse the phase of a periodic signal, which is to be supplied to a transmission conductor, to assure high detection sensitivity.

[0156] FIG. 23 illustrates a supplying form of a periodic signal in modification 8. Referring to FIG. 23, modification 8 is configured such that, between the multi-frequency signal supplying circuit 21 and the transmission conductor selection circuit 22 of the transmission section 20 shown in FIG. 1, a phase inversion circuit 87 for inversing the phase of a periodic signal produced by each periodic signal production section 24 is provided. When a periodic signal of a predetermined frequency f_k is supplied to a transmission conductor Y_{n+1}, the phase inversion circuit 87 inverses the phase of the periodic signal of the frequency f_k and supplies the periodic signal of the inversed phase to a transmission conductor Y_n. Then, in the reception section 30 shown FIG. 1, currents output from the two reception conductors X_{n+1} and X_n positioned adjacent to each other are input to a two-input one-output amplifier 90. Both input terminals of the amplifier 90 are non-negated (+) terminals.

[0157] Where the phase inversion circuit 87 is used in the transmission section 20, when a pointer is not positioned in proximity, signals output from the two reception conductors X_{n+1} and X_n to be used for detection simultaneously cancel each other and therefore, the detection sensitivity can be improved.

[Modification 9]

[0158] In modification 8 described above, in order to enhance the detection sensitivity, a periodic signal produced by the transmission section and an inverted phase signal having a phase inverse to that of the periodic signal are utilized and a two-input one-output amplifier is used in the reception section. However, in order to achieve enhancement of the detection sensitivity and expansion of the range for detection without using an inverted phase signal, a periodic signal having the same frequency may be supplied to a plurality of transmission conductors while a plural-input one-output amplifier is used in the reception section.

[0159] FIG. 24 illustrates a supplying form of a periodic signal and a detection form of an output signal according to modification 9. Referring to FIG. 24, a two-input one-output amplifier 90 with two inputs being non-negated (+) terminals is used in the reception section 30. Where the amplifier 90 is used, periodic signals of the same frequency are supplied to two transmission conductors 14.

[0160] Where periodic signals of the same frequency are supplied to a plurality of transmission conductors 14 and output signals from a plurality of reception conductors 12 are added, not only the level of the output signal to be detected can be increased, but also the detection range can be expanded. Where output signals of a plurality of reception conductors are added, since the detection range can be expanded, the configuration described is suitable particularly where the position detection region of the sensor section 10 is large.

[0161] In modification 9 described above, periodic signals of the same frequency are supplied in a unit of two transmission conductors 14, while output signals of two reception conductors 12 are added in the reception section. However, the number of transmission conductors 14, to which periodic signals of the same frequency are to be supplied, may be three or more, and the number of reception conductors 12 whose outputs are to be added by an amplifier of the reception section may also be three or more accordingly.

[0162] Further, while in modification 9, the number of reception conductors 12 whose outputs are added by an amplifier is equal to the number of transmission conductors 14 to which periodic signals of the same frequency are supplied, the present invention is not limited to such arrangement. The number of transmission conductors 14 to which periodic signals of the same frequency are to be supplied and the number of reception conductors 12 whose outputs are to be added by an amplifier may be different. Where the number of transmission conductors 14, to which periodic signals of the same frequency are to be supplied and the number of reception conductors 12 whose outputs are to be added by an amplifier are set equal to each other, the following advantages can be achieved.

[0163] In particular, where the number of transmission conductors, to which periodic signals of the same frequency are to be transmitted, is different from the number of reception conductors 12, whose outputs are to be added by an amplifier, the minimum detection region on the sensor section 10 has a rectangular shape, resulting in production of anisotropy in sensitivity distribution. In this instance, if the sensor section 10 detects a pointer whose face opposing the sensor section 10 has a circular shape (such face is hereinafter referred to as "opposing face"), the opposing face of the pointer is not detected as a circular shape but as a deformed shape, like an elliptic shape. On the other hand, where the number of transmission conductors, to which periodic signals of the same frequency are to be transmitted, is equal to the number of reception conductors 12, whose outputs are to be added by an amplifier as in modification 9, the minimum detection region S_{min} on the sensor section 10 has a square shape, and an isotropic sensitivity distribution is obtained. In this instance, when a pointer with a circular opposing face is disposed on the sensor section 10, the opposing face of the pointer can be detected as a circular shape.

[0164] In the first embodiment described above with reference to FIG. 5, rotation of a frequency is carried out in an example wherein each periodic signal to be supplied to the transmission conductors 14 in a transmission block 25 has a different frequency from each other. However, where periodic signals of the same frequency are supplied to each of two transmission conductors 14 positioned adjacent to each other, as in the case of modification 9, the frequency may be rotated after every predetermined period of time as described above. Different examples are illustrated in FIGS. 25A and 25B and

[0165] FIGS. 26A to 26C.

[0166] In the example of rotation illustrated in FIGS. 25A and 25B, periodic signals of a frequency f_0 having the same phase are supplied to the transmission conductors Y_2 and Y_3 first at a certain ,time, as seen in FIG. 25A. Then, after a predetermined interval of time, periodic signals of the frequency f_0 having the same phase are supplied to the transmission conductors Y_0 and Y_1 as seen in FIG. 25B. In short, in the example of rotation of FIGS. 25A and 25B, the transmission conductors 14, to which periodic signals of the same frequency are to be supplied, are shifted or displaced in a unit of two transmission conductors after every predetermined interval of time.

[0167] Where the rotation wherein the transmission conductors 14, to which periodic signals of the same frequency are to be supplied, are displaced in a unit of two transmission conductors in this manner, detection of a pointer can be carried out at a higher speed.

[0168] In the example of rotation illustrated in FIGS. 26A to 26C, periodic signals of the frequency f_0 having the same phase are supplied to the transmission conductors Y_2 and Y_3 at a certain time as seen in FIG. 26A. After a predetermined interval of time, periodic signals of the frequency f_0 having the same phase are supplied to the transmission conductors Y_1 and Y_2, as seen in FIG. 26B. Then, after an equal predetermined interval of time elapses, periodic signals of the frequency f_0 having the same phase are supplied to the transmission conductors Y_0 and Y_1, as seen in FIG. 26C. In short, in the example of FIGS. 26A to 26C, the transmission conductors 14, to which periodic signals of the same frequencies are to be supplied, are displaced by one transmission conductor after every predetermined interval of time.

[0169] With the rotation wherein the transmission conductors 14, to which periodic signals of the same frequency are to be supplied, are displaced in a unit of one transmission conductor after every predetermined interval of time, since periodic signals of the same frequency are supplied to a plurality of transmission conductors 14, the detection accuracy can be enhanced in comparison with the example according to the first embodiment described above with reference to FIG. 5.

[Modification 10]

[0170] In modification 9 described above, the number of reception conductors 12 whose outputs are to be added by an amplifier on the reception side is increased by two, three or more so that the level curve of the output signals becomes broader to expand the detection range. However, if the number of reception conductors is increased in the frequency multiplex system (particularly one that does not use a differential amplifier), there is a possibility that the level of the current flowing into the reception conductors by synthesis of the periodic signals may become much higher than the level suited for detection. As a result, the dynamic range of an amplifier or the like of the reception section 30 may be exceeded and the amplifier may become saturated. FIG. 27 illustrates an example of a level curve detected in modification 9 shown in FIG. 24, wherein the level curve 90X includes steep rising and falling edges and also indicates a high level. When the number of reception conductors 12 increases to three, four and so forth, the reception level further rises and the current flowing into the reception conductors increases by synthesis of periodic signals. Therefore, in modification 10, in order to suppress current flowing into reception conductors by synthesis of periodic signals while broadening the level curve of the output signal, a reception conductor connected to the ground is provided between the other reception conductors. An example is shown in FIG. 28.

[0171] FIG. 28 illustrates a supplying form of periodic signals and a detection form of an output signal in modification 10. Referring to FIG. 28, in modification 10, a three-input one-output amplifier 91 having threes input terminals is used. The three input terminals are formed such that the opposite side ones thereof are non-negated (+) terminals while the central one thereof is connected to the ground. The central input terminal is hereinafter referred to as "0" terminal. The input terminals of the amplifier 91 are connected to the reception conductor selection circuit 31 described above with reference to FIG. 1. In particular, reception conductors X_m and X_{m+2} positioned on the opposite sides of arbitrary three reception conductors X_m to X_{m+2} of the reception conductor selection circuit 31, which are positioned adjacent to each other, are connected to the non-negated terminals on the opposite sides of the amplifier 91. The reception conductor X_{m+1} of the reception conductor selection circuit 31 that is positioned centrally is connected to the "0" terminal of the amplifier 91. In other words, the level of an output signal from the central reception conductor X_{m+1} is zero.

[0172] In the configuration just described, the output signal output from the amplifier 91 in modification 10 exhibits a level curve 91 X illustrated in FIG. 28. In particular, as seen in FIG. 28, the level curve 91X has a broad curved shape having a magnitude equal to or smaller than that of the "++" reception by two reception conductors, while having a breadth substantially equal to that of the "+++" reception by three reception conductors. In modification 10, as the curved shape of the level curve 91X becomes broader, the maximum value thereof is suppressed to a value lower than that where three reception conductors are involved. The value may also be lower than that where two reception conductors are involved. The detection range is substantially the same as that where three reception conductors are involved. Further, connecting one of the reception conductors to the ground plays a role similar to that where a pointer is connected to the ground.

[0173] Since the output signal from the reception conductor X_{m+1} connected to the ground is zero, the central one of three transmission conductors may be connected to the ground in accordance with the connection condition of the reception conductors. Where the configuration just described is used, it contributes not only to improvement of the level curve of an output signal to be detected, but also to suppression of power consumption. Further, since small swells are generated by multiplexing of periodic signals even if a differential amplifier is used, the transmission side may use a connection scheme which exhibits a similar signal level in a corresponding relationship to the connection scheme of the reception side.

[0174] Where a reception conductor to be connected to the ground is provided between other reception conductors as described above, the shape of the level curve can be made broad while swells of the level curve remain suppressed. Therefore, output signals can be detected at the same time through a plurality of reception conductors while the level of the level curve is suppressed, and the coordinate recognition characteristic is improved. Further, the detection range can be expanded to a plurality of reception conductors while suppressing the level of the level curve.

[0175] FIG. 29 illustrates another supplying form of periodic signals and another detection form of an output signal in modification 10. Referring to FIG. 29, in the example of modification 10, a four-input one-output amplifier 92 having four input terminals is used. The four input terminals of the amplifier 92 include non-negated (+) terminals and "0" terminals arranged alternately. The "0" terminals are connected to the ground. The input terminals are connected to the reception conductor selection circuit 31 described above with reference to FIG. 1. In particular, arbitrary four reception conductors X_m to X_{m+3} of the reception conductor selection circuit 31, which are positioned adjacent to each other, are respectively connected to the non-negated terminals and the negated terminals of the amplifier 92. In particular, of the four adjacent reception conductors X_m to X_{m+3}, the reception conductors X_{m+1} and X_{m+3} are connected to the ground so that the level of the output signals from the reception conductors X_{m+1} and X_{m+3} is set to zero. Alternate ones of the transmission conductors Y_n to Y_{n+3}, that is, the transmission conductors Y_n and Y_{n+2}, may be connected to the ground in a corresponding relationship to the connection scheme of the reception conductors, as seen in FIG. 29. Further, another configuration is possible wherein the reception conductors X_{m-1} and X_{m+1} are connected to the "0" terminals while the reception conductors X_m and X_{m+2} are connected to the non-negated terminals.

[0176] In this example, for example, if a four-input one-output amplifier is used and all of the input terminals of the same are non-negated terminals, that is, if four arbitrary reception conductors selected by the reception conductor selection circuit 31 are used to carry out "++++" reception, the level curve of the output signal will exceed the dynamic range of the amplifier 92 due to swells and so forth based on synthesis of periodic signals, resulting in saturation of the amplifier 92. However, where "+0+0" or "0+0+" reception is carried out (alternate ones of the reception conductors are connected to the ground), although an equal number of reception conductors are used, the level curve of the output signal is not saturated.

[0177] According to the example of modification 10 described above with reference to FIG. 29, a plurality of periodic signals of the same frequency are supplied to the corresponding transmission conductors 14 and output signals from alternate ones of the reception conductors 12 are added similarly as in the example described above with reference to FIG. 28. In the configuration described, the detection range can be expanded while current flowing into the reception conductors is suppressed to a suitable degree, and the level of the output signal to be detected can be increased. Therefore, the detection sensitivity can be enhanced. Further, the example of modification 10 described above with reference to FIG. 29 is suitable particularly where the position detection region on the sensor section 10 is great since the detection range can be expanded and the level of the output signal to be detected can be increased similar to the example of FIG. 28.

[0178] In modification 10 illustrated in FIGS. 28 and 29, the supplying pattern of periodic signals of the same frequency to the transmission conductors 14 is the same as the connection pattern of the reception conductors 12 whose outputs are to be added by an amplifier. In this instance, the minimum detection region on the sensor section 10 becomes a square shape, and an isotropic distribution is obtained.

[Modification 11]

[0179] As an example for improving the noise resisting property of an output signal to be detected by the reception section 30, a configuration which uses a differential amplifier to carry out differential driving is available. An example of a supplying form of periodic signals and a detection form of an output signal where four reception conductors form a detection range is illustrated in FIG. 30. FIG. 30 illustrates modification 11, which uses a four-input one-output differential amplifier 93. The four input terminals of the differential amplifier 93 include negated (-) terminals and non-negated (+)

terminals disposed such that the terminals of the same polarity are disposed in a neighboring relationship with each other. Thus, the reception conductors X_m and X_{m+1} from arbitrary four reception conductors X_m to X_{m+3} of the reception conductor selection circuit 31 shown in FIG. 1 are connected to the non-negated terminals of the differential amplifier 93, while the reception conductors X_{m+2} and X_{m+3} are connected to the negated terminals of the differential amplifier 93.

[0180] Where the signal detection form of the reception section is "++--" as in modification 11, the signal supplying form of the transmission section is preferably set in conformity with the signal detection form. In particular, periodic signals having "negative, negative, positive, positive" phases in the ascending order of the indexes of the transmission conductors 14 are supplied to the four transmission conductors Y_n to Y_{n+3} positioned adjacent to each other. In order to implement this, periodic signals of a frequency f_k are supplied to the transmission conductors Y_{n+2} to Y_{n+3} without changing the phase thereof, as seen in FIG. 30. Meanwhile, periodic signals of the frequency f_k are supplied through phase inversion circuits 87 to the transmission conductors Y_n to Y_{n+1}.

[0181] In this example, a level curve 93X illustrated in FIG. 30 represents the level or output value of the output signal originating from the four reception conductors 12. Where the differential amplifier 93 with the configuration described above is used in the reception section, noise included in a synthetic signal of the reception conductors X_m and X_{m+1} and a synthetic signal of the reception conductors X_{m+2} and X_{m+3} cancel each other in the differential amplifier 93. Therefore, the noise resisting property can be enhanced.

[0182] Where a differential amplifier is used, the level variation of the output signal obtained when a pointer actually touches the sensor section exhibits an S-shaped characteristic, as indicated by a broken line in FIG. 30. In order to calculate the position of the pointer, the output signal must have one peak value, as in the level curve 93X. This is because a reception conductor, which exhibits the peak value, indicates the position at which the pointer actually touches. Such an output signal, which has one peak value as just described, can be obtained by applying an integration process to an output signal having an S-shaped characteristic indicated by a broken line in FIG. 30. However, the integration process accumulates noise, and the position detection accuracy may thus deteriorate.

[0183] Therefore, in modification 11, the same number of input terminals of different polarities can be arranged in the left and right portions of a differential amplifier of the reception section 30 such that left and right output signals to be detected are balanced. An example is shown in FIG. 31.

[0184] FIG. 31 illustrates an example of a supplying form of periodic signals and a detection form of an output signal where the detection range includes four reception conductors. Referring to FIG. 31, in the example shown, a four-input one-output differential amplifier 94 is used. The four input terminals of the differential amplifier 94 are disposed such that the non-negated (+) terminals and the negated (-) terminals are symmetrical with each other in the leftward and rightward direction. The reception conductor selection circuit 31 shown in FIG. 1 is connected to the differential amplifier 94 such that arbitrary four reception conductors X_m to X_{m+3} positioned adjacent to each other are connected to the four input terminals of the differential amplifier 94. In particular, of the four adjacent reception conductors X_m to $X_{m+3,}$ the reception conductors X_{m+1} and X_{m+2} are connected to the non-negated terminals of the differential amplifier 94 and the reception conductors X_m and X_{m+3} are connected to the negated terminals. In the transmission section 20, it is preferable to arrange the supplying pattern of periodic signals to match the polarities of the input terminals of the differential amplifier 94 to which the reception conductors 12 are connected. Specifically, of arbitrary four transmission conductors Y_n to Y_{n+3} positioned adjacent to each other and selected by the transmission conductor selection circuit 22, periodic signals of the frequency f_k are supplied to the transmission conductors Y_{n+1} to Y_{n+2}, while, to the transmission conductors Y_n to Y_{n+3}, periodic signals having a phase reversed from that of the periodic signals of the frequency f_k are supplied through the phase inversion circuit 87.

[0185] An output signal obtained from the differential amplifier 94 in modification 11 has one peak value as seen from a level curve 94X illustrated in FIG. 31. As a result, since the necessity for an integration process of an output signal of the differential amplifier is eliminated, the noise resisting property can be improved. Therefore, a signal when the sensor section is pointed by a pointer can be detected with certainty.

[0186] While in modification 11 described above, the number of reception conductors to be connected to a differential amplifier is four, the number of reception conductors is not limited to four or any even number. It may also be a unit of an odd number, such as three or five. Further, the phase reversal may be carried out not only on the reception conductors side, but also on the transmission conductors side or on both of the reception conductors side and the transmission conductors side. Further, the central reception conductor may be connected to the ground or to an arbitrary reference potential as in the example of FIG. 28.

[0187] Further, while the disposition of the input terminals of the differential amplifier in modification 11 described above is "-++-," the disposition of the input terminals is not limited to this example, and it is only necessary for the input terminals to be disposed symmetrically in the leftward and rightward direction. Thus, FIG. 32 illustrates a different example of a supplying form of periodic signals and a detection form of an output signal where the detection range includes four reception conductors.

[0188] Referring to FIG. 32, a four-input one-output differential amplifier 95 is used, and the input terminals of the differential amplifier 95 are disposed such that non-negated (+) terminals and negated (-) terminals are switched relative to those used in modification 11 described above with reference to FIG. 31. The reception conductor selection circuit 31 described above with reference to FIG. 1 is connected to the differential amplifier 95 such that arbitrary four reception conductors X_m to X_{m+3} positioned adjacent to each other of the reception conductor selection circuit 31 are connected to the four input terminals of the differential amplifier 95. In particular, from the four adjacent reception conductors X_m to X_{m+3}, the reception conductors X_m and X_{m+3} are connected to the non-negated terminals of the differential amplifier 95, while the reception conductors X_{m+1} and X_{m+2} are connected to the negated terminals of the differential amplifier 95. In the transmission section 20, of arbitrary four transmission conductors Y_n to Y_{n+4} positioned adjacent to each other and selected by the transmission conductor selection circuit 22, to the transmission conductors Y_n and Y_{n+3} periodic signals of the frequency f_k are supplied. To the transmission conductors Y_{n+1} and Y_{n+2}, periodic signals having a phase reversed from that of the periodic signals of the frequency f_k are supplied through the phase inversion circuit 87. As a result, the supplying pattern of periodic signals corresponds to the polarities of the input terminals of the differential amplifier 95, to which the reception conductors 12 are connected. In other words, in the example of FIG. 32, the disposition of the input terminals of the differential amplifier 95 is "+--+." In the case of "+--+" also, the necessity for an integration process of an output signal of the differential amplifier is eliminated similar to the example described above with reference to FIG. 31. Consequently, the noise resisting property can be improved.

[Modification 12]

[0189] While, in modification 11 described above, the detection range includes four reception conductors, in modification 12, the detection range includes three reception conductors.

[0190] FIG. 33A illustrates a supplying form of periodic signals and a detection form of an output signal where the detection range includes three reception conductors, as modification 12, and FIG. 33B illustrates an example different from modification 12 of FIG. 33A.

[0191] In the example of FIG. 33A, a three-input one-output differential amplifier 96 is used. The three input terminals of the differential amplifier 96 are disposed such that the non-negated (+) terminal and the negated (-) terminals are symmetrical with each other in the leftward and rightward direction. Then, the reception conductor selection circuit 31 described above with reference to FIG. 1 is connected to the differential amplifier 96 such that arbitrary three reception conductors X_m to X_{m+2} of the reception conductor selection circuit 31 positioned adjacent to each other are connected to the three input terminals of the differential amplifier 96. More particularly, of the three reception conductors X_m to X_{m+2} positioned adjacent to each other, the reception conductor X_{m+1} is connected to the non-negated terminal, and the reception conductors X_m and X_{m+2} are connected to the negated terminal. Meanwhile, in the transmission section 20, to the transmission conductor Y_{n+1} from among arbitrary three transmission conductors Y_n to Y_{n+2} positioned adjacent to each other and selected by the transmission conductor selection circuit 22, periodic signals of the frequency f_k are supplied. To the transmission conductors Y_n and Y_{n+2}, periodic signals having a phase reversed from that of the periodic signals of the frequency f_k are supplied through the phase inversion circuit 87. As a result, the supplying pattern of periodic signals corresponds to the polarities of the input terminals of the differential amplifier 96 to which the reception conductors 12 are connected.

[0192] In the example of FIG. 33B, the polarities of the input terminals of the differential amplifier of FIG. 33A are reversed. In particular, a three-input one-output differential amplifier 97 is used. The three input terminals of the differential amplifier 97 are disposed such that the non-negated (+) terminals and the negated (-) terminal are symmetrical with each other in the leftward and rightward direction. Then, the reception conductor selection circuit 31 described above with reference to FIG. 1 is connected to the differential amplifier 97 such that arbitrary three reception conductors X_m to C_{m+2} of the reception conductor selection circuit 31 positioned adjacent to each other are connected to the three input terminals of the differential amplifier 97. More particularly, of the three reception conductors X_m to X_{m+2} positioned adjacent to each other, the reception conductors X_m and X_{m+2} are connected to the non-negated terminal and the reception conductor X_{m+1} is connected to the negated terminal. Meanwhile, in the transmission section 20, to the transmission conductors Y_n and Y_{n+2} from among arbitrary three transmission conductors Y_n to Y_{n+2} positioned adjacent to each other and selected by the transmission conductor selection circuit 22, periodic signals of the frequency f_k are supplied. To the transmission conductor Y_{n+1}, a periodic signal having a phase reversed from that of the periodic signals of the frequency f_k is supplied through the phase inversion circuit 87. As a result, the supplying pattern of period signals corresponds to the polarities of the input terminals of the differential amplifier 97 to which the reception conductors 12 are connected.

[0193] In the examples illustrated in FIGS. 33A and 33B, in order to establish a balanced state between output signals obtained at the input terminals of different polarities, an output signal obtained from a terminal of one polarity, to which a comparatively smaller number of reception conductors are connected, and output signals obtained at terminals of the other polarity, to which a comparatively greater number of reception conductors are connected, are balanced with each other. In particular, the level of an output signal obtained at the "+ (-)" terminal of the differential amplifier 96 (97) is increased to twofold, and both this output signal increased to twofold and output signals obtained at the other two "- (+)"

terminals are used. In this example, to what extent (i.e., to what number of times) the level of the output signal obtained at an input terminal or terminals of a polarity for which the number of terminals provided is comparatively small is to be increased, is determined based on both the number of input terminals of the polarity with which the number of reception terminals connected is comparatively small and the number of input terminals of the other polarity with which the number of reception terminals connected is comparatively great.

[0194] With modification 12, even where the number of conductors to be detected is a unit of an odd number, left and right output signals detected upon detection waiting can be balanced with each other similar to the examples of modification 11 illustrated in FIGS. 31 and 32. Further, with modification 12, the minimum detection region S_{min} can be reduced in comparison with that in modification 11 in addition to the effect that the noise resisting property is improved similarly to modification 11.

[Modification 13]

[0195] Modification 13 is modification to the first embodiment in that a nonlinear process is carried out for a level curve or level characteristic of an output signal obtained when a pointer actually touches the sensor section. Modification 13 is described with reference to FIGS. 34 and 35.

[0196] FIG. 34 illustrates a signal level upon ordinary detection of a finger. Usually, a level curve 101 of an output signal obtained by the reception section 30 when a pointer such as a finger 19 touches the detection surface of the sensor section 10 has such a characteristic as seen in FIG. 34. The level of the output signal obtained upon touching by the pointer is very high at the touched location of the sensor section 10. On the other hand, the level of the output signal is very low at a portion of the sensor section 10 at which the pointer is spaced from the sensor section 10, that is, at a non-touched portion of the sensor section 10. Even if a recognition process is carried out at a location where the pointer is spaced a little from the sensor section 10, the level of the output signal is very different between the two cases (the touched vs. non-touched) and, therefore, an accurate recognition process is difficult.

[0197] Thus, in modification 13, an output signal obtained upon touching by a pointer is subjected to a detection process by the signal detection circuit 34, and then to logarithmic transformation. Where nonlinear transformation such as logarithmic transformation is carried out, a signal portion of the output signal, which has a comparatively low level and corresponds to a non-touched portion of the sensor section 10, can be made to stand out while the signal level of another signal portion, which has a comparatively high level and corresponds to a touched portion of the sensor section 10, can be suppressed.

[0198] FIG. 35 illustrates an example of a level curve after the nonlinear process of the output signal represented by the level curve 101 in the example of FIG. 34. The level curve 102 in the example of FIG. 35 has a suppressed maximum value and is broadened. Therefore, the level of the output signal continues between adjacent reception conductors at the boundary between a touched portion and a non-touched portion of the sensor section 10 by the pointer. Consequently, a boundary recognition process for the pointer can be readily carried out. It is to be noted that a nonlinear process for the output signal is not limited to the logarithmic transformation and other suitable processes may be used.

[0199] According to the example described, an output signal obtained upon touching by a pointer is nonlinearly transformed once. Consequently, an output signal continues between adjacent reception conductors at the boundary between a touched portion and a non-touched portion of the sensor section 10. Therefore, a boundary recognition process for the pointer can be readily carried out. Accordingly, a recognition characteristic with respect to a pointer can be improved. Such extraction of a surface area that is touched by the pointer including the boundary is important for the purpose of detecting a pointer coordinate, a pointer pressure, and so forth, as will be described later. Particularly when the pointer moves on the sensor section, a coordinate error that may otherwise occur when the pointer crosses over between reception conductors (i.e., a selection error of a reception conductor before and after such crossing over) can be reduced.

[Modification 14]

[0200] Modification 14 is an example in which identification of a state wherein a pointer is spaced away from the detection surface of the sensor section in the first embodiment is carried out satisfactorily. The state described is hereinafter referred to as hovering.

[0201] Identification of whether or not a pointer touches the sensor section is conventionally recognized based only on a gradient 102A of an edge, that is, a rising edge, of a level curve of an output signal obtained from the reception conductors of the sensor section, as seen in FIG. 35. For example, when the gradient 102A is steep, it is identified that a pointer 19 is touching the sensor section, but when the gradient 102A is moderate, it is identified that a pointer is spaced away from the sensor section.

[0202] However, if a setting of the amplifier varies, accurate identification of a touching state becomes difficult. A method that identifies a hovering situation without being influenced by a detected level variation of the output signal is described below with reference to FIGS. 34 to 36.

[0203] In modification 14, a hovering situation is identified from a maximum value of the level curve of the output signal obtained from the reception conductors of the sensor section and a form of the level curve. The maximum value of the level curve is hereinafter referred to as a peak value. Therefore, the pointer detection apparatus of modification 14 includes ratio calculation means for detecting a peak value, which is the length of an arrow mark in FIG. 35, and the gradient 102A of an edge of the level curve, and dividing the gradient 102A of the edge by the peak value to determine a ratio. It further includes hovering identification means for identifying whether or not the pointer is in a hovering state depending upon whether or not the ratio is higher than a predetermined threshold value. In particular, the signal detection circuit 34 is provided with the ratio calculation means and the hovering identification means, and a result of the identification by the signal detection circuit 34 is transmitted to the position calculation circuit 35. Alternatively, the functions of the ratio calculation means and the hovering identification means may be provided in the control circuit 40.

[0204] The hovering identification means has stored therein a predetermined threshold value for deciding whether or not the pointer is in a hovering state, and has a function of comparing the ratio between the peak value and the gradient 102A of the edge as determined by the ratio calculation means with the predetermined threshold value. If the ratio between the peak value and the gradient 102A of the edge is higher than the predetermined threshold value, the hovering identification means decides that the pointer is in a non-hovering state, that is, the pointer is touching the sensor section. If the ratio between the peak value and the gradient 102A of the edge calculated by the ratio calculation means is lower than the predetermined threshold value, the hovering identification means decides that the pointer is in a hovering state, that is, the pointer is not in touch with the sensor section. Further, the hovering identification means may set a second threshold value lower than the predetermined threshold value, and compare the second threshold value and the ratio between the peak value and the gradient 102A of the edge determined by the ratio calculation means with each other. A degree of the hovering situation may thus be identified more particularly.

[0205] An example of determination of a peak value and a gradient of an edge is described with reference to FIG. 36. FIG. 36 illustrates an example of normalized levels of output values of output signals detected by the reception section 30. The present example represents a normalized value of the level of an output signal detected during a certain instantaneous time period, using three transmission conductors and three reception conductors. Since the level 100 as a maximum value is detected at the center and the level 50 is detected on the left and right sides of the center in the direction along a transmission conductor, the gradient of the edge in this instance is 100 - 50 = 50. Then, since the maximum value of the level curve of the output signal is 100, the value of the ratio to be determined is the gradient of edge/maximum value = 50/100 = 0.5. In the example illustrated in FIG. 36, the peak value and the gradient of the edge of the output signal are determined from the level curve 102 illustrated in FIG. 35 obtained by the non-linear process. They may otherwise be determined from the level curve 101 before the non-linear process.

[0206] According to the example illustrated in FIG. 36, since a hovering situation is identified based on a maximum value of the level curve of the detected output signal and a ratio of the shape of the level curve, stable identification of a hovering situation becomes possible. Therefore, the identification of a hovering situation is not influenced by the level variation of the output signal obtained from the reception conductors of the sensor section.

[Modification 15]

[0207] Modification 15 is an example suitable to carry out detection of hovering with certainty in the first embodiment.

[0208] Where hovering at a certain cross point or in a detection area is to be detected, if a predetermined number is selected as the number of transmission conductors and reception conductors which are to be rendered operative at the same time, then the number of conductors to be selected later is fixed. However, where this configuration is used, the detection sensitivity of hovering may become low as the influence of noise increases significantly. Therefore, reliable detection of hovering becomes difficult.

[0209] In modification 15, the number of transmission conductors and reception conductors to be rendered operative at the same time is dynamically varied. This operation is described with reference to FIGS. 37 and 38.

[0210] FIG. 37 illustrates a supplying form of periodic signals and a detection form of an output signal where a pointer is positioned in proximity to the sensor section. FIG. 38 illustrates a supplying form of periodic signals and a detection form of an output signal where a pointer is not positioned in proximity to the sensor section.

[0211] The example shown FIGS. 37 and 38 has a configuration similar to that of modification 9 described above with reference to FIG. 24. In modification 15 of FIG. 37, a four-input one-output amplifier 98 whose four input terminals have the polarity of "+" is used in the reception section 30.

[0212] In the example of FIG. 37, two transmission conductors 14, which are positioned adjacent to each other, are selected to utilize two input terminals from among the four input terminals. In the transmission section 20, periodic signals of the same frequency are preferably supplied to two adjacent ones of the transmission conductors 14. Where a pointer is positioned in proximity to the sensor section, two transmission conductors 14 and two reception conductors 12 are selected to detect a current variation. Whether or not a pointer is positioned in proximity to the sensor section can be detected using modification 13 described above with reference to FIGS. 34 and 35 or modification 14 described above with reference to FIGS. 35 and 36.

[0213] In the example illustrated in FIG. 38, the four-input one-output amplifier 98 is used in the reception section 30, and the transmission section 20 selects four adjacent ones of the transmission conductors 14 to which periodic signals are to be supplied. Preferably, the periodic signals to be supplied from the transmission section 20 have the same frequency and are supplied to four transmission conductors 14 positioned adjacent to each other. In this manner, where a pointer is not positioned in proximity to the sensor section, four transmission conductors 14 and four reception conductors 12 are selected to increase the number of conductors to be used.

[0214] Such selection of the reception conductors 12 and the transmission conductors 14 is carried out by the control circuit 40. The control circuit 40 receives an output from the position calculation circuit 35 to decide the distance between the sensor section and the pointer, and based on a result of the decision issues an instruction regarding a position and a number of conductors to be selected to both the transmission conductor selection circuit 22 and the reception conductor selection circuit 31.

[0215] A particular example of hovering operation is described with reference to FIGS. 1, 37 and 38.

[0216] It is assumed that two transmission conductors 14 and two reception conductors 12 are selected at a certain time to execute scanning, as seen in FIG. 37. The following description is given assuming that periodic signals having different frequencies from each other are supplied at the same time from the multi-frequency signal supplying circuit 21 to all transmission conductors 14, which form the transmission conductor group 13.

[0217] In this instance, the control circuit 40 first controls the reception conductor selection circuit 31 to select, for example, the reception conductors X_{m+1} and X_{m+2}. In this state, the reception section 30 carries out detection of a pointer using the selected reception conductors X_{m+1} and X_{m+2}. After the detection process by the reception section 30 is completed, the control circuit 40 controls the reception conductor selection circuit 31 to displace the reception conductors to select the reception conductors X_{m+3} and X_{m+4}, for example. Then, the reception section 30 carries out detection using the newly selected reception conductors X_{m+3} and X_{m+4}. Thereafter, selection of the reception conductors 12 and detection of a pointer as just described are repeated to carry out scanning of the entire sensor section 10. Here, if the reception section 30 cannot detect a pointer, that is, if an output from the amplifier 98 is not detected, the control circuit 40 controls the reception conductor selection circuit 31 to increase the number of reception conductors 12 to be selected by the reception conductor selection circuit 31, for example, to four, as seen in FIG. 38, and thereafter executes scanning.

[0218] Where the number of reception conductors 12 to be selected by the reception conductor selection circuit 31 is increased from two to four in this manner, since the number of output signals to be input from the reception conductors to the amplifier increases to four, the detection accuracy increases. Further, since the number of conductors to be selected increases from two to four, the time required for scanning the entire sensor section can be reduced, also.

[0219] While in modification 15 the number of conductors to be selected by the reception conductor selection circuit 31 is two or four, the number of conductors is not limited to four, but may be any number. Further, the number of reception conductors 12 to be selected at the same time is not limited to four. In other words, the control circuit 40 may control the reception conductor selection circuit 31 so that, as the distance between the sensor section and the pointer increases, the number of conductors to be selected by the reception conductor selection circuit 31 is gradually increased. Further, while, in the example of FIGS. 37 and 38, the amplifier described is of the type which carries out single (input) end operation, an amplifier of differential operation may be used instead. In modification 15, periodic signals having different frequencies from each other are supplied at the same time from the multi-frequency signal supplying circuit 21 to all transmission conductors 14 which form the transmission conductor group 13. However, periodic signals to be supplied from the transmission section 20 may be changed over similarly, e.g., by gradually increasing the number of transmission conductors 14 that receive the same frequency signals.

[0220] In the present example, if it is decided that no pointer exists in proximity to the sensor section, the number of transmission conductors 14 and reception conductors 12 to be used is controlled so as to increase the detection sensitivity. Accordingly, reliable hovering detection can be implemented.

[Modification 16]

[0221] Modification 16 is an example suitable for advantageously carrying out all scanning desired to be carried out at a high speed with increased sensitivity. In particular, it is directed to roughly detecting a pointer in response to a signal level of a detection signal detected by the sensor section.

[0222] In the present description, "all scanning" means to sequentially carry out a detection process for a current variation (i.e., scanning) to cover all cross points on the sensor section in order to detect a pointer. It is desired that all scanning is carried out at a high speed with increased sensitivity. However, if all scanning of the transmission conductors and the reception conductors is carried out for each conductor or for each group of a small number of conductors, the sensitivity decreases, and since the number of scanning points is large, the time required for all scanning becomes long.

[0223] Therefore, in modification 16, if an output signal is not detected from the sensor section, the number of transmission conductors and reception conductors to be used for a single-time detection process is increased (as compared to that used in all scanning) to make rough scanning of scanning points (hereinafter referred to as "skip scanning"). In the skip scanning, the minimum detection region is made greater, and a detection process for a current variation is carried out using the minimum detection region as a minimum unit of displacement or shifting.

[0224] In order to implement the skip scanning, the signal detection circuit 34 is provided with a function of detecting presence or absence of an output signal. The signal detection circuit 34 transmits a result of the detection to the control circuit 40. The control circuit 40 receives the result of detection from the signal detection circuit 34 and controls the number of conductors to be selected by the transmission conductor selection circuit 22 and the reception conductor selection circuit 31 based on the received detection result. If a pointer is not detected, that is, if an output signal is not detected, the control circuit 40 controls the transmission conductor selection circuit 22 and the reception conductor selection circuit 31 to increase the number of transmission conductors 14 and reception conductors 12 to be used for transmission and reception of signals. If a pointer is detected, that is, if an output signal is detected, the control circuit 40 controls the transmission conductor selection circuit 22 and the reception conductor selection circuit 31 to decrease the number of transmission conductors 14 and reception conductors 12 to be selected by the transmission conductor selection circuit 22 and the reception conductor selection circuit 31, respectively.

[0225] A particular example of the skip scanning is described with reference to FIGS. 1 and 38.

[0226] If all scanning is carried out but an output signal is not detected, the control circuit 40 controls the transmission conductor selection circuit 22 and the reception conductor selection circuit 31 so that four conductors, that is, four transmission conductors Y_n to Y_{n+3} and four reception conductors X_m to X_{m+3}, may be selected from the transmission conductors 14 and the reception conductors 12 to initiate skip scanning. Then, after scanning is carried out for the selected four reception conductors X_m to X_{m+3}, the control circuit 40 controls the reception conductor selection circuit 31 to shift the reception conductors to be selected to carry out scanning of the reception conductors X_{m+4} to X_{m+7} (not shown). Thereafter, the control circuit 40 repeats selection and scanning of the transmission conductors 14 and the reception conductors 12, and changeover of the transmission conductors 14 and the reception conductors 12 to be selected by the transmission conductor selection circuit 22 and the reception conductor selection circuit 31, to repeat the operation for the entire sensor section 10. Then, if a pointer is detected at any step, the control circuit 40 stops the skip scanning and executes all scanning using a smaller group of transmission conductors 14 and reception conductors 12 to be selected.

[0227] Where the number of reception conductors to be selected at the same time is changed to four as in the skip scanning of the present example, the sensitivity is increased. Further, since the detection position is shifted by a greater amount, in addition to the increased sensitivity, the detection time required for the entire sensor section is reduced. While in the example described the number of conductors to be selected at the same time during skip scanning is four, it is not limited to this particular number. The number of conductors to be selected during skip scanning may be any arbitrary number greater than that used in all scanning, for example, two, three or five. Further, while the number of reception conductors to be changed over (i.e., switched or shifted) is four, the number of reception conductors to be changed over is not limited to this number. For example, where four reception conductors are to be selected, they can be shifted by two, three or four conductors. In particular, in the description above using displacement by four conductors, reception is carried out using the reception conductors X_m to X_{m+3} first, and then the reception conductors to be selected are changed over to the reception conductors X_{m+4} to X_{m+7}, and so forth. However, displacement by two conductors is possible, wherein reception is carried out first using the reception conductors X_m to X_{m+3}, and then the reception conductors to be selected are changed over to the reception conductors X_{m+2} to X_{m+5}, and so forth. Further, while both of the transmission conductors and the reception conductors are selected four by four, the number of the transmission conductors may be different than the number of the reception conductors to be selected.

[0228] Further, while it is described that both the number of transmission conductors and the number of reception conductors to be selected are increased or decreased at the same time based on the level of the output signal, other arrangements are possible. For example, only the number of transmission conductors or the number of reception conductors may be increased or decreased. Various methods can be applied as long as the effective area, that is, the minimum detection region within which an output signal can be detected, is increased or decreased.

[0229] The number of transmission conductors and reception conductors to be used may be changed depending not only upon detecting the presence or absence of an output signal but also upon the degree of the level of the output signal. For example, when the level of the output signal is higher than a predetermined threshold value set in advance, the number of conductors is decreased, but when the level of the output signal is lower than the predetermined threshold value, the number of conductors is increased. Further, not one threshold value but a plurality of threshold values may be set. As a method of detecting the level of the output signal, the method of modification 13 described above with reference to FIGS. 34 and 35, modification 14 described above with reference to FIGS. 35 and 36 or the like may be used.

[0230] In the present example, when a pointer is not detected, the number of transmission conductors and reception conductors to be selected at the same time is increased to carry out rough scanning of scan points, that is, to initiate skip scanning. Where the number of conductors is set in this manner, the detection sensitivity can be improved and high speed scanning can be implemented. Therefore, if modification 16 is applied to the first embodiment, that is, to the frequency multiplexing method, the time required for one cycle of scanning the entire sensor section 10 can be reduced significantly in comparison with the conventional systems because of a synergistic effect with the frequency multiplexing.

[Modification 17]

[0231] Modification 17 is suitable to more accurately detect a touched location of the sensor section by a pointer or detect a pointer positioned in proximity to the sensor section in the first embodiment.

[0232] As described in connection with the first embodiment illustrated in FIG. 2 and modification 1 illustrated in FIG. 14 as well as modification 2 illustrated in FIG. 15, the sensor section may have the transmission conductors and the reception conductors disposed with a spacer interposed therebetween, in two layers with a glass substrate interposed therebetween, or disposed in the same layer. Generally, in a structure which uses a spacer or a glass substrate, that is, in the structure wherein the distance between the detection surface and the transmission conductors is different than the distance between the detection surface and the reception conductors, the intensities of an electric field acting between the detection surface and the transmission and reception conductors are different. Therefore, the level curve of an output signal from a conductor spaced away from the detection surface of the sensor section exhibits a broad shape while the level curve of an output signal from a conductor in proximity to the detection surface of the sensor section exhibits a sharp shape. In other words, the gradient of an edge of the level of an output signal from a conductor spaced away from the detection surface is moderate, while the gradient of an edge of the level curve of an output signal from a conductor in proximity to the detection surface is steep.

[0233] FIG. 39 illustrates a supplying form of periodic signals and a detection form of an output signal where the number of transmission conductors and reception conductors is five. In the example of FIG. 39, a five-input one-output differential amplifier 99 is used. The five input terminals of the differential amplifier 99 include a "0" terminal at the center thereof and two non-negated (+) terminals and two negated (-) terminals disposed on the opposite sides of the "0" terminal. Five reception conductors X_m to X_{m+4} positioned adjacent to each other are connected to the input terminals. In particular, of the five reception conductors X_m to X_{m+4} positioned adjacent to each other, the reception conductors X_m and X_{m+1} are connected to the negated terminals, the reception conductor X_{m+2} is connected to the "0" terminal, and the reception conductors X_{m+3} and X_{m+4} are connected to the non-negated terminals. Meanwhile, five transmission conductors 14 are connected so as to correspond in polarity to the input terminals of the differential amplifier 99, to which the reception conductors 12 are connected. In particular, the central transmission conductor Y_{n+2} is grounded, and periodic signals of the frequency f_k are supplied to the two transmission conductors Y_n and Y_{n+1}, while periodic signals having a phase reversed from that of the periodic signals supplied to the transmission conductors Y_n to Y_{n+1} are supplied to the two transmission conductors Y_{n+3} to Y_{n+4}.

[0234] Where the structure of the sensor section in FIG. 39 is the same as that of the sensor section 50 of modification 1 described above with reference to FIG. 14, because the reception conductors 12 are disposed at a position nearer to the detection surface than the transmission conductors 14, the level curve of the output signals of the transmission conductors 14 becomes a broad curve. The level curve of the output signals of the reception conductors 12 becomes a sharp curve. Because a difference appears between the shapes of the level curves where they are viewed from the reception side and from the transmission side, even if the pointer has a round shape, there is the possibility that it may be detected as an elliptic shape, as indicated by a broken line in FIG. 39.

[0235] Therefore, in modification 17, the pointer detection apparatus is configured such that the detection width on those conductors which are disposed remotely from the detection surface of the sensor section is narrow, while the detection width on those conductors which are disposed nearer to the detection surface of the sensor section is wide. No difference may appear between the shapes or detection widths of the level curves of the output signals on the reception side and the transmission side.

[0236] FIG. 40 illustrates a supplying form of periodic signals and a detection form of an output signal by modification 17. Referring to FIG. 40, the sensor section has the same structure as that of the sensor section 50 of modification 1, similar to the example described above with reference to FIG. 39, and uses the same differential amplifier 99.
The example of FIG. 40 is different from the example of FTG. 39 in that three transmission conductors 14 are selected so that periodic signals are supplied thereto, wherein the central transmission conductor Y_{n+2} from the three selected transmission conductors 14 is grounded, and a periodic signal is supplied to the transmission conductor Y_{n+1} and to the transmission conductor Y_{n+3} after the phase thereof is reversed by a phase inversion circuit 87.

[0237] In the above configuration, if the level curve of the output signals is represented by a three-dimensional representation, and the shape of the level curve is cut away with a certain threshold value, the shapes or detection widths of the level curve portions of the output signals on the transmission side and the reception side are substantially the same. Therefore, no difference appears in the detection widths. As a result, the shape to be detected becomes a substantially round shape as indicated by a broken line in FIG. 40. In other words, the aperture ratios or aspect ratios on the transmission side and the reception side can be adjusted.

[0238] In modification 17, the sensor section is used wherein transmission conductors and reception conductors both having a substantially linear shape are juxtaposed, However, in place of the transmission conductors and the reception conductors having a linear shape, conductors having a land portion having a width greater than that of the conductor portions as in the case of modification 3 described above may be used. Further, the transmission conductors and the reception conductors may be formed with an arbitrary width. Also regarding the disposition pattern of the transmission conductors and the reception conductors, they may be formed in a juxtaposed concentric relationship with each other as in the case of modification 5, and also regarding the pitch between the conductors, it may be changed to an arbitrary pitch. Further, not only a differential amplifier but also an amplifier of a single (input) end configuration may be used.

[0239] In the present example, the pointer detection apparatus is configured such that the detection width of the conductors spaced far away from the detection face of the sensor section is comparatively narrow while the detection width of the conductors positioned in proximity to the detection face of the sensor section is comparatively broad. Therefore, no difference may appear between the shapes or detection widths of the level curves of the output signals on the reception side and the transmission side, and the aperture ratio or aspect ratio can be made close to 1. In other words, the shape of a portion of a pointer at which the pointer touches the detection surface can be recognized with a higher degree of accuracy. For example, a round shape can be detected as a round shape without being deformed to an elliptic shape.

[Modification 18]

[0240] Modification 18 is an example suitable to appropriately control the gain of a received output signal (such gain is hereinafter referred to as "reception gain") based on the level or output value of the entire output signals received from the sensor section in the first embodiment.

[0241] In the first embodiment, a signal of a particular frequency component is detected from within an output signal by the synchronous detection circuit 37 shown in FIG. 10 of the signal detection circuit 34, and the level of the detected signal of the particular frequency component (such signal is hereinafter referred to as "detection signal") is used (referenced) by an automatic gain control circuit (not shown) or the control circuit 40 to determine a reception gain. Then, the reception gain is set in the amplification circuit 32. However, where a signal other than the particular frequency component, that is, noise, is input to the synchronous detection circuit 37, or where a plurality of signals having different frequencies are received, the intensity of a combined signal cannot be obtained readily and the reception gain of the amplification circuit 32 cannot be set appropriately. As a result, there is the possibility that the output signal may be saturated in the amplification circuit 32.

[0242] Therefore, modification 18 provides not only means for detecting a particular frequency component from within output signals of the reception conductors 12, but also means for obtaining a signal level of all frequency components of the output signals and, further, means for referring to the signal level of all frequency components to set a reception gain.

[0243] FIG. 41 shows a block configuration of the reception section of the pointer detection apparatus according to modification 18. FIG. 42 shows a block configuration of an absolute value detection circuit 39A. In the example of FIG. 41, an absolute value detection circuit 39A for detecting an energy component is given as an example of the means for obtaining the level of all frequency components of the output signals. In the example of FIG. 42, an automatic gain control circuit 39B for acquiring the level of all frequency components from the absolute value detection circuit is provided as an example of the means for referring to the level of the signal of all frequency components to set a reception gain.

[0244] As seen in FIGS. 41 and 42, the absolute value detection circuit 39A is provided in the signal detection section 34a in the first embodiment described above with reference to FIG. 9, and the automatic gain control circuit 39B is coupled to (or provided in) the absolute value detection circuit 39A.

[0245] As seen in FIG. 42, the absolute value detection circuit 39A includes, as principal components thereof, an input terminal 390, a multiplier 391 for carrying out arithmetic operation of squaring the level of a detection signal or output signal, and an integrator 392 for integrating the output of the multiplier 391. If a detection signal is input from a reception conductor 12 to an absolute value detection circuit 39A through the A/D conversion circuit 33, then the detection signal is branched by the input terminal 390 and supplied to the multiplier 391. Both of the two branched detection signals are input to and subjected to squaring operation by the multiplier 391. Then, the detection signal squared by the multiplier 391 is input to and temporarily integrated by the integrator 392, and output.

[0246] The absolute value detection may be carried out not by the method of integrating an energy component obtained by squaring an output signal described above, but by another method of integrating the absolute value of the level of the output signal. Any method may be used by which the level of a signal including a signal of all frequency components and noise can be detected. Further, the absolute value detection process may be carried out by any of digital signal processing means and analog circuit means.

[0247] In the present example, the pointer detection apparatus is configured such that the reception gain is set based on the level of a signal obtained by absolute value detection of output signals of the reception conductors 12, that is, of a signal of all frequency components. Thus, the level of received signals including a plurality of signals of different frequencies and noise can be detected to set the reception gain appropriately.

[Modification 19]

[0248] Modification 19 is an example suitable to compensate for a drop of the level or a delay of the phase of a periodic signal due to floating capacitance of the transmission conductors and the reception conductors, which serve as transmission lines, in the first embodiment. Modification 19 is described with reference to FIGS. 43A, 43B, 44A, and 44B.

[0249] In the first embodiment, periodic signals are supplied from one side of the transmission conductors 14. FIG. 43A illustrates a supplying form of periodic signals in a one-side supplying scheme, and FIG.43B shows a graph representing the level of output signals when a periodic signal is applied to a transmission conductor Y_k. In FIG. 43B, the axis of abscissa of the graph represents the position of the reception conductors 12, and the axis of ordinate represents the level of the output signals.

[0250] As the distance from the supplying side of a periodic signal, in the example of FIG. 43A, from the right end of a transmission conductor 14, increases, that is, toward the reception conductor X_m remote from the reception conductor X_{m+8}, which is positioned near to the supplying side of a periodic signal, the level of the output signal drops. Similarly, the phase delay increases from the reception conductor Xmas side toward the remote reception conductor X_m. A level difference and a phase difference appear between the reception conductor X_{m+8} near the supplying side of a periodic signal and the reception conductor X_m remote from the supplying side, which causes coordinate displacement upon position calculation. Particularly where the sensor section is formed using ITO, the resistance value of the ITO is high and the sensor section is subjected to a rather substantial influence by the transmission line.

[0251] Therefore, in modification 19, the transmission section including the multi-frequency signal supplying circuit 21 and the transmission conductor selection circuit 22 is provided at each of the opposite ends of the transmission conductors 14 so that periodic signals are supplied at the same time from the left and the right to the transmission conductors 14.

[0252] FIG. 44A illustrates a supplying form of periodic signals where the transmission sections are provided at the opposite ends of the transmission conductors 14 in modification 19, and FIG. 44B shows a graph representing the level of output signals when a periodic signal is supplied to the transmission conductor Y_k in modification 19. In FIG. 44B, the axis of abscissa of the graph represents the position of the reception conductors 12 and the axis of ordinate represents the level of the output signals.

[0253] As seen in FIG. 44B, as the distance from the reception conductors X_m and X_{m+8} which are positioned near the supplying sections of a periodic signal increases, the level of the output signal drops. Here, since the distance from the reception conductors X_m and X_{m+8} on the opposite ends of the reception conductors 12 to the remote reception conductor X_{m+4} is one half the distance between the reception conductor X_m and the reception conductor X_{m+8} which are farthest apart in the example of FIG. 44A, the level drop of the output signal decreases to one half. Simultaneously, the phase delay decreases to one half.

[0254] In the present example, the periodic signal supplying sections are provided on the opposite sides of the transmission conductors. As an alternative, output signals of the transmission conductor selection circuit 22 shown in FIG. 1 may be branched so as to be supplied to the opposite ends of the transmission conductors 14. As described above, a periodic signal need not be provided to a single transmission conductor 14 at a time, but may be provided to a plurality of transmission conductors.

[0255] Since a periodic signal is supplied at the same time from the transmission sections provided at the opposite ends of a transmission conductor 14, the level drop and the phase delay of the periodic signal can be moderated in comparison with those including a conventional one-side supplying system. Hence, the level difference and the phase difference among the reception conductors 12 decrease considerably, thereby suppressing the drop in detection sensitivity.

[Modification 20]

[0256] Modification 20 is suitable to detect a pressure when a pointer touches the detection surface of the sensor section in the first embodiment. A pressure exerted by a pointer is hereinafter referred to as finger pressure (though, of course, a pointer is not limited to a human finger in accordance with the present invention).

[0257] Heretofore, the finger pressure was calculated based on the assumption that it has a proportional relationship to the area on the detection surface of the sensor section that is touched by the finger (hereinafter "touched area"). Therefore, if a person having a small finger and another person having a large finger depress the detection surface with equal force, then the touched area of the person having a small finger is smaller than that of the person having a large finger. In addition, even if the person having a small finger depresses the detection surface with large force, the conventional finger pressure system may recognize it as a light touch. Therefore, in modification 20, the pointer detection apparatus is configured such that the finger pressure exerted by a pointer such as a finger touching the detection surface is detected based on a spatial distribution or level curved face of the level of the detected output signals.

[0258] FIG. 45A illustrates an example of a spatial distribution or level curved face of the level of detected output signals when a pointer touches the detection surface of the sensor section.

[0259] The level curved face 110 of the output signals is determined from the variation of current at cross points of the sensor section. The level curved face 110 is calculated, for example, by the position calculation circuit 35 shown in FIG. 1 which analyzes the output of the signal detection circuit 34. Here, the coordinate of a transmission conductor 14 which is positioned substantially at the center of the touched area at which a high level value is obtained is represented by "0," and the coordinates of the transmission conductors 14 disposed from the left to right sides of the centrally positioned transmission conductor 14 ("0") are represented by"..., -3, -2, -1, 1, 2, 3, ..." The reception conductors 12 are similarly arranged. The level values of the level curved face 110 are in a normalized form. As seen in FIG. 45A, the level curved face 110 exhibits a mountain-like shape having an apex or summit substantially at the center of the touched area, and a finger pressure is estimated using the volume of a portion of (or under) the level curved face 110 cut across (horizontally in FIG. 45A) at a predetermined level value.

[0260] FIG. 45B shows one simple method of determining the volume of an upper space when the level curved face 110 is cut across at a predetermined level, which entails dividing the level curved face 110 into a plurality of (vertical) planes and determining the volume by summing the area values of the planes, that is, two-dimensional level values of the planes.

[0261] Referring to FIG. 45B, an example of division of the level curved face 110 into a plurality of planes is shown. In the example of FIG. 45B, the level curved face 110 is divided into a plurality of planes 111 to 115 along those transmission conductors whose coordinates range from "-2" to "2," respectively. First, the area of each of the planes 111 to 115 is determined, and the areas of the planes 111 to 115 are summed to obtain a volume of the level curve 101. At this time, the area is determined preferably with regard to those of the planes 111 to 115 whose apex levels are higher than the predetermined level value.

[0262] While, in the example described above, the sum of the areas of the planes into which the level curved face is divided is used as the volume of the level curved face, alternatively the level values may be weight-added in a numerical analysis. Further, the calculation method of the volume is not limited to summing up the values associated with divisional planes. The volume may be calculated, for example, by applying multi-dimensional curved face approximation, such as trapezoidal shape approximation and square approximation.

[0263] One method of determining the volume of an upper space of the level curved face 110 when it is cut out at a predetermined level value is described with reference to FIG. 46. FIG. 46 illustrates a relationship between the position of transmission conductors and the area of divisional planes (as shown in FIG. 45B). The axis of abscissa indicates the position of transmission conductors, and the axis of ordinate indicates the area of planes.

[0264] Referring to FIG. 46, data points S_1 to S_5 on a curve 120 represent the values of areas determined with regard to the planes 111 to 115 of FIG. 45B, respectively. Further, in FIG. 46, the coordinates "-2" to "2" of the transmission conductors and respectively connected by line segments with the corresponding data points S_1 to S_5 on the curve 120. Further, each adjacent ones of the data points S_1 to S_5 are interconnected by a line segment. Consequently, four trapezoids are formed between the positions "-2" to "2" of the transmission conductors.

[0265] The volume of the level curved face 110 to be determined corresponds to the area of a portion surrounded by the axis of abscissa of FIG. 46, that is, the straight line between the positions "-2" and the "2" of the transmission conductors, and the curve 120. To calculate this area, however, the method described above (the level curved face is divided into a plurality of planes and the volume is determined from the sum value of the areas of the planes, that is, the two-dimensional level values of the planes) may be less than satisfactory and contain a rather substantial error because the volume is determined simply by adding the discrete values of the data points S_1 to S_5.

[0266] Therefore, in the example of FIG. 46, trapezoid approximation is used to determine the sum value of the areas of the four trapezoids, that is, the area of a portion indicated by slanting lines in FIG. 46, to approximate the volume of the level curved face 110.

[0267] First, a weight value is applied to each data point in accordance with trapezoid approximation. For example, weight 1 is applies to the data point S_1, 2 to the data point S_2, 2 to the data point S_3, 2 to the data point S_4 and 1 to the data point S_5. The volume V_1 is determined by dividing the "sum value of the weighted areas at the transmission conductors, that is, at the data points" by an "average value of the weight values included in the trapezoids." In particular, the volume V_1 is given by:

$$\text{Volume } V_1 = (1*S_1 + 2*S_2 + 2*S_3 + 2*S_4 + 1*S_5)/2$$

Here, the average value of the weight values is determined by dividing the "sum total of the weight values at the data points" by the "number of the trapezoids." In the example above, (1 + 2 + 2 + 2 + 1)/4 = 2.

It is also possible to use square approximation for the calculation. In this instance, weight values applied to the data points are squared to calculate the volume V_2 similarly as described above. In particular, the volume V_2 is given by:

$$\text{Volume } V_2 = (1{*}S_1 + 4{*}S_2 + 4{*}S_3 + 4{*}S_4 + 1{*}S_5)/3.5$$

Here, the average value of the weight values is obtained by dividing the "sum of square values of the weight values at the data points" by the "number of trapezoids." In the present example, (1 + 4 + 4 + 4 + 1)/4 = 3.5

[0268] Since the error (discrepancy) between the hypotenuses of the four trapezoids and the curve 120 is small as seen in FIG. 46, the error between a calculation result obtained using the trapezoid approximation, that is, the area of the portion indicated by slanting lines, and the actual volume of the level curved face 110, becomes small. As a result, the calculation result obtained using the trapezoid approximation indicates an accurate volume in comparison with a calculation result obtained by summing the divisional areas of the planes into which the level curved face is divided. Further, where the approximation calculation is used to determine the volume, the calculation is simpler than that obtained by summing the areas of the divisional planes of the level curved face. Therefore, the load applied to the position calculation circuit 35 can be reduced.

[0269] The pressure per unit area may be calculated by dividing the volume of the level curved face by the touched area. In this instance, the volume determined as described above can be divided by a touch area 110A illustrated in FIG. 45 to determine the pressure per unit area.

[0270] In the present example, the finger pressure when a pointer (e.g., a finger) touches the detection surface of the sensor section is detected based on the volume determined using the areas of a plurality of planes into which the level curved face is divided, that is, using two-dimensional level values. Use of the determined volume value as the finger pressure allows for accurate finger pressure detection, which is reflective of an actual touching force exerted by a user.

[0271] Various modifications to the first embodiment described heretoabove can be applied also to the second to fourth embodiments to be described below unless a specific restriction is involved.

<2. Second Embodiment>

[Configuration of the Pointer Detection Apparatus]

[0272] As described hereinabove in connection with the first embodiment and modifications 6 to 12 and 15 to 17 to the first embodiment, in the pointer detection apparatus of the present invention, periodic signals of different frequencies from each other can be supplied to a plurality of transmission conductors 14, and output signals from a plurality of reception conductors 12 can be input collectively to one amplifier. Further, a single pointer detection apparatus may selectively incorporate and switch between one or more configurations described above in connection with modifications 6 to 12 and 15 to 17, depending on each application, a required sensitivity, or the like. In particular, a single pointer detection apparatus may be configured to selectively vary the supplying form of periodic signals to the transmission conductor group 13 and the detection form of output signals from the reception conductor group 11 depending on each application, a required sensitivity, or the like. FIG. 47 shows an example of such a pointer detection apparatus. In FIG. 47, elements like those in the first embodiment described above with reference to FIG. 1 are denoted by like reference characters and overlapping description of them is omitted herein to avoid redundancy.

[0273] Referring to FIG. 47, the pointer detection apparatus 150 of the second embodiment includes a sensor section 10, a transmission section 151, a reception section 153, and a control circuit 40 for controlling operation of the transmission section 151 and the reception section 153. The sensor section 10 and the control circuit 40 respectively have a similar configuration to that in the first embodiment.

[0274] The transmission section 151 includes a multi-frequency signal supplying circuit 21, a transmission conductor connection pattern changeover circuit 152, a transmission conductor selection circuit 22 and a clock generation circuit 23. The multi-frequency signal supplying circuit 21, transmission conductor selection circuit 22 and clock generation circuit 23 respectively have a configuration similar to that in the first embodiment.

[0275] The transmission conductor connection pattern changeover circuit 152 is a circuit which, for example, selectively changes over (or switches) a supplying form of periodic signals to be supplied to the transmission conductors 14. In particular, the transmission conductor connection pattern changeover circuit 152 suitably selects the number and the position of transmission conductors 14 to which periodic signals are to be supplied, the frequencies of periodic signals to be supplied, and so forth, in accordance with each application or the like. For example, the transmission conductor connection pattern changeover circuit 152 selects one of the supplying forms of periodic signals and so forth described above in connection with modifications 6 to 12 and 15 to 17. The selection and changeover operation of a supplying form by the transmission conductor connection pattern changeover circuit 152 is controlled by the control circuit 40. A configuration of the transmission conductor connection pattern changeover circuit 152 is hereinafter described.

[0276] The transmission conductor selection circuit 22 includes a plurality of switches. The transmission conductor selection circuit 22 selects an output terminal of the transmission conductor connection pattern changeover circuit 152 and a corresponding one of the transmission conductors 14 in response to the supplying form of periodic signals selected by the transmission conductor connection pattern changeover circuit 152. The transmission conductor selection circuit 22 connects the selected output terminal of the transmission conductor connection pattern changeover circuit 152 and the selected transmission conductor 14 to each other. The selection and changeover operation of the transmission conductors 14 by the transmission conductor selection circuit 22 is controlled by the control circuit 40.

[0277] Referring to FIG. 47, the reception section 153 includes a reception conductor selection circuit 31, a reception conductor connection pattern changeover circuit 154, an amplification circuit 32, an A/D conversion circuit 33, a signal detection circuit 34 and a position calculation circuit 35. The reception conductor selection circuit 31, amplification circuit 32, A/D conversion circuit 33, signal detection circuit 34 and position calculation circuit 35 respectively have a configuration similar to that in the first embodiment.

[0278] The reception conductor connection pattern changeover circuit 154 is a circuit which, for example, selectively changes over (or switches) a detection form of output signals from the reception conductor group 11 in response to a supplying form of periodic signals to the transmission conductors 14. In particular, the reception conductor connection pattern changeover circuit 154 suitably selects the number and the positional relationship of reception conductors 12 to be connected to one amplifier, a process such as addition or subtraction to be carried out by the amplifier, and so forth, in response to the supplying form of periodic signals, each application, and so forth. For example, the reception conductor connection pattern changeover circuit 154 selects one of the detection forms of an output signal described above in connection with modifications 6 to 12 and 15 to 17. The selection and changeover operation of a supplying form by the reception conductor connection pattern changeover circuit 154 is controlled by the control circuit 40.

[0279] The reception conductor selection circuit 31 is a circuit section that includes a plurality of switches and selectively connects input terminals of the reception conductor connection pattern changeover circuit 154 to corresponding ones of the reception conductors 12, in response to the detection form of output signals selected by the reception conductor connection pattern changeover circuit 154. The selection and changeover operation of the reception conductors 12 by the reception conductor selection circuit 31 is controlled by the control circuit 40.

[Changeover (Switching) of the Transmission Conductors]

[0280] Where a configuration described above is adopted, one pointer detection apparatus can suitably set a supplying form of periodic signals to the transmission conductor group 13 and a detection form of output signals from the reception conductor group 11 depending on each application, a required sensitivity, and so forth.

[0281] While in the first embodiment described above, one transmission conductor 14 is selected for every predetermined period of time from within each transmission block 25 (refer to FIGS. 1 and 5) of the transmission conductor group 13, in the present second embodiment, periodic signals of different frequencies are supplied at the same time to all transmission conductors 14 which form a transmission block, to carry out position detection. Then, after every predetermined period of time, a new transmission block is selected, to which periodic signals having different frequencies are supplied at the same time to carry out position detection.

[0282] In the following, an example of switching of transmission conductors by the present embodiment is described with reference to FIGS. 48, 49A and 49B. In the present example, one transmission block 161 includes 16 transmission conductors 14 positioned adjacent to each other. Since one transmission block 161 includes 16 adjacent transmission conductors 14, the number of frequencies f_k of periodic signals to be supplied to each of the transmission blocks 161 is "16." Accordingly, the number of periodic signal production sections in the multi-frequency signal supplying circuit 21 (refer to FIG. 47) which supply the periodic signals is 16. Since the switching operation illustrated in FIG. 49B is different from that illustrated in FIG. 49A only in that the direction of rotation of the switching operation of the transmission blocks 161 is reversed, description is given only of the example of FIG. 49A.

[0283] As seen in FIG. 48, the transmission conductor connection pattern changeover circuit 152 includes 16 switches 152a. The transmission conductor connection pattern changeover circuit 152 is provided between the multi-frequency signal supplying circuit 21 and the transmission conductor selection circuit 22 and receives periodic signals supplied thereto from the multi-frequency signal supplying circuit 21.

[0284] The switches 152a are provided in order to supply periodic signals received from the multi-frequency signal supplying circuit 21 to the transmission conductors 14, which form a transmission block 161. The switches 152a are individually connected to frequency production sections 24 of the multi-frequency signal supplying circuit 21 (refer to FIG. 47). The transmission conductor connection pattern changeover circuit 152 carries out switching operation under the control of the control circuit 40.

[0285] FIGS. 49A and 49B illustrate an example of switching operation of the transmission conductors.

[0286] First, a state where periodic signals of frequencies f_0 to f_{15} are supplied at the same time to transmission conductors Y_0 to Y_{15} of the transmission block (Yo to Y_{15}) is described in reference to FIG. 49A.

[0287] The periodic signals of the frequencies f_0 to f_{15}, output from the frequency production sections 24 (refer to FIGS. 3 and 47) of the multi-frequency signal supplying circuit 21, are supplied to the transmission conductors Y_0 to Y_{15}

of the transmission block {Y_0 to Y_{15}} through the switches 152a, which form the transmission conductor connection pattern changeover circuit 152. While the periodic signals of the frequencies f_0 to f_{15} are supplied to the reception section 153, the reception section 153 carries out position detection. After the position detection is carried out by the reception section 153, the transmission conductor connection pattern changeover circuit 152 switches to the next transmission block, {Y_{16} to Y_{31}} for example, to which the periodic signals are to be supplied, under the control of the control circuit 40. Thus, the periodic signals of the frequencies f_0 to f_{15} are supplied to the transmission conductors Y_{16} to Y_{31}, respectively, at the same time. Then, after every predetermined interval of time, the transmission conductor connection pattern changeover circuit 152 switches to the subsequent transmission block 161, to which the periodic signals are to be supplied, i.e., to the transmission block {Y_{32} to Y_{47}}, and so forth, and position detection is repeated for each new transmission block. Then, if the supply of the periodic signals to the last transmission block {Y_{48} to Y_{63}} and the position detection therewith are completed, the transmission conductor connection pattern changeover circuit 152 switches to the first transmission block, {Y_0 to Y_{15}}, to which the periodic signals are to be again supplied, under the control of the control circuit 40, and the switching operation described above is repeated. In the present example, the transmission block, to which the periodic signals are to be supplied, returns to the original (first) transmission block in the fourth switching operation.

[0288] Where the switching operation of the transmission conductors 14, the transmission conductor selection circuit 22, and the transmission conductor connection pattern changeover circuit 152 are configured as described above, the following effect can be achieved. For example, if one transmission conductor 14 is selected after a predetermined time interval ΔT from each transmission block of the transmission conductor group 13 as in the first embodiment, the difference in detection time between those transmission conductors 14 which are positioned on each boundary between the transmission blocks 161 becomes great (e.g., the detection time differs greatly between Y_{15} and Y_{16}). This will be described with a specific example below.

[0289] In this example, it is assumed that a pointer is positioned between the transmission conductors Y_{15} and Y_{16} in the first embodiment, and that the periodic signals supplied from the multi-frequency signal supplying circuit 21 are supplied to the transmission conductors Yo tlxroughY$_{63}$ in their corresponding transmission blocks {Y_0 to Y_{15}}, {Y_{16} to Y_3}, {Y_{32} to Y_{47}}, {Y_{48} to Y_{63}}, respectively (refer to FIG. 48). The pointer is detected by the reception section 30, and the transmission conductor selection circuit 22 switches to the transmission conductors 14 successively in a direction in which the index increases after every predetermined time interval ΔT under the control of the control circuit 40 to detect the position of the pointer. In this instance, the time difference after the periodic signals supplied from the multi-frequency signal supplying circuit 21 are supplied to the transmission conductors Y_{15} and Y_{16} until the periodic signals are supplied to the transmission conductors Y_{15} and Y_{16} subsequently, is 16ΔT. In this instance, if the pointer is moving in proximity to the boundary between transmission blocks 161 (e.g., between the transmission conductors Y_{15} and Y_{16}), the detection accuracy of the pointer is decreased.

[0290] In contrast, in the present second embodiment, since the transmission conductors 14 are switched per a unit of transmission block 161, the difference in detection time between the transmission conductors 14 positioned on the boundary between transmission blocks 161 is short (ΔT). As a result, even if the pointer is moving in proximity to the boundary between transmission blocks 161, the pointer can be detected with a higher degree of accuracy.

[Changeover (Switching) of the Reception Conductors]

[0291] In the first embodiment described above, one reception conductor 12 is selected from within each of the detection blocks 36 of the reception conductor group 11 after every predetermined period of time. In the present second embodiment, position detection is carried out at the same time for each detection block, and after a predetermined interval of time, position detection is carried out with regard to another detection block.

[0292] An example of the switching of reception conductors in the second embodiment is described with reference to FIG. 50 and 51. It is assumed that one detection block 163 is formed from 16 reception conductors 12 that are positioned adjacent to each other. Since one detection block 163 is formed from 16 reception conductors 12 positioned adjacent to each other, the number of I/V conversion circuits 32a (i.e., amplifiers) in the amplification circuit 32 is equal to the number of the reception conductors 12 which form the detection block 163. In other words, the number of the I/V conversion circuits 32a in the amplification circuit 32 is 16.

[0293] FIG. 50 shows an example of a configuration of a reception conductor connection pattern changeover circuit 154 which carries out the switching operation in the present example. The reception conductor connection pattern changeover circuit 154 includes 16 switches 154a. The reception conductor connection pattern changeover circuit 154 is provided between the reception conductor selection circuit 31 and the amplification circuit 32, and receives reception signals supplied thereto from the reception conductor selection circuit 31.

[0294] The switches 154a supply reception signals supplied thereto from the reception conductor selection circuit 31 at the same time to the I/V conversion circuits 32a, which form the amplification circuit 32. The switches 154a are respectively connected to the I/V conversion circuits 32a of the amplification circuit 32. The reception conductor connection pattern changeover circuit 154 carries out the switching operation under the control of the control circuit 40 shown in FIG. 47.

[0295] An example of the switching operation of the reception conductors is illustrated in FIG. 51. Referring to FIG. 51, the reception conductor connection pattern changeover circuit 154 switches (i.e., changes over) the switches 154a under the control of the control circuit 40 to connect all reception conductors 12 in the detection block {X_0 to X_{15}} to the I/V conversion circuits 32a forming the amplification circuit 32, as shown in FIG. 9. Then, the reception section 153 carries out position detection of a pointer at the same time with regard to all of the connected reception conductors 12 within the detection block.

[0296] After the reception section 153 completes the position detection, the reception conductor connection pattern changeover circuit 154 switches the switches 154a to be connected from the previous detection block {X_0 to X_{15}} to the next detection block {X_{16} to X_{31}}, to thereby connect all of the reception conductors 12 in the next detection block 163 to the I/V conversion circuits 32a under the control of the control circuit 40. Then, the reception section 153 carries out position detection of a pointer at the same time with regard to all of the connected reception conductors 12 within the next detection block. Thereafter, the switching operation described is carried out repetitively. When the position detection with regard to the last detection block {X_{112} to X_{127}} ends, the reception conductor connection pattern changeover circuit 154 switches the switches 154a, under the control of the control circuit 40, to again connect the first detection block {X_0 to X_{15}} to the I/V conversion circuits 32a, and repeats the switching operation described above. In this example, the reception conductor connection pattern changeover circuit 154 returns to the same (e.g., the first) detection block in the eighth switching operation.

[0297] Where the switching operation of the reception conductors 12, the reception conductor selection circuit 31, and the reception conductor connection pattern changeover circuit 154 are configured as described above, the following effect can be achieved. In particular, if one reception conductor 12 is selected after every predetermined time interval Δt from within each detection block of the reception conductor group 11 as in the first embodiment, the difference in detection time between those reception conductors 12, which are positioned on each boundary between the detection blocks, becomes great (e.g., the detection time differs greatly between X_{15} and X_{16}). More particularly, if the reception conductors X_0, X_{16}, ..., X_{112} are detected in the detection blocks {X_0 to X_{15}}, {X_{16} to X_{31}}, ..., {X_{112} to X_{127}}, respectively, and the reception conductors 12 are switched successively in the direction in which the index increases after every predetermined time interval Δt, the detection time difference between the reception conductors X_{15} (the 16th in the first detection block) and X_{16} (the 1st in the second detection block) is as great as 15Δt. In this instance, if a pointer is moving in proximity to the boundary between detection blocks such as between the reception conductors X_{15} and X_{16}, the detection accuracy of the pointer is decreased due to the large detection time difference between the two reception conductors.

[0298] In contrast, in the present embodiment, since the reception conductors 12 are switched per a unit of detection block 163, the difference in detection time between reception conductors 12, which are positioned on the boundary between the detection blocks 163, becomes as short as Δt. As a result, even if a pointer is moving in proximity to the boundary between detection blocks, the pointer can be detected with a high degree of accuracy.

[Modification 1]

[0299] In modification 1 of the second embodiment, another example of rotation of the switching operation of the transmission conductors 14 is applied. The pointer detection apparatus in modification 1 has the same configuration as that of the second embodiment, and therefore, the description of the same is omitted herein to avoid redundancy.

[0300] Modification 1 is different from the second embodiment in that, while in the rotation in the second embodiment, the changeover (switching) of the 16 switches 152a which form the transmission conductor connection pattern changeover circuit 152 is carried out per a unit of transmission block 161, in the rotation in modification 1, the switching is carried out by successively shifting the 16 switches 152a one by one in a direction in which the index of the transmission conductor 14 decreases (or increases). Examples of the rotation of the switching operation of the transmission conductors in modification 1 are illustrated in FIGS. 53A and 53B. The switching operation in FIG. 53B is different from that in FIG. 53A only in that the direction of rotation of the switching operation is reverse to that in the example of FIG. 53A. Therefore, description is given only of the example of FIG. 53A.

[0301] First, the periodic signals of the frequencies f_0 to f_{15} supplied from the multi-frequency signal supplying circuit 21 are supplied at the same time to the 16 transmission conductors Y_{48}, Y_{49}, Y_{50}, ... and Y_{63} which are positioned adjacent to each other, that is, which have consecutive indexes n. While the periodic signals of the frequencies f_0 to f_{15} remain supplied, the reception section 30 carries out position detection.

[0302] After a predetermined interval of time, the control circuit 40 controls the transmission conductor connection pattern changeover circuit 152 to switch the transmission conductors, to which the frequencies f_0 to f_{15} are to be supplied via the switches 152a, by one transmission conductor in a direction in which the index n decreases. (Switches 152a form the transmission conductor connection pattern changeover circuit 152.) In particular, the periodic signals of the frequencies f_0 to f_{15} are now supplied at the same time to the transmission conductors Y_{47} to Y_{62}, respectively. While the periodic signals of the frequencies f_0 to f_{15} remain supplied, the reception section 153 carries out position detection. Such switching operation is repeated until the periodic signals of the frequencies f_0 to f_{15} are supplied to the transmission conductors Y_0 to Y_{15}, respectively, and the reception section 153 carries out position detection. Thereafter, the control circuit 40 controls the transmission conductor connection pattern changeover circuit 152 to switch the transmission conductors connected to the switches 152a, from the transmission conductors Y_0 and Y_1 to Y_{15} to the transmission conductors Y_{63} and Y_0 to Y_{14}, respectively. Then, the reception section 153 carries out position detection operation similar to that described above.

[0303] With such rotation of the switching operation of the transmission conductors 14 as in the present example, the following effect can be achieved. In particular, periodic signals are supplied to 16 transmission conductors positioned adjacent to each other, and a group formed of 16 transmission conductors positioned adjacent to each other is shifted by one transmission conductor such that position detection is carried out in a concentrated manner at a particular portion. Therefore, the detection accuracy can be improved.

<3. Third Embodiment>

[0304] In a third embodiment, another example of rotation of switching operation of transmission conductors 14 is used. The pointer detection apparatus of the third embodiment has the same configuration as that of the first embodiment, and therefore, overlapping description of the configuration is omitted herein to avoid redundancy.

[0305] The third embodiment is different from the first embodiment in that, while the rotation in the first embodiment is carried out such that each of the frequencies f_0 to f_{15} supplied from the multi-frequency signal supplying circuit 21 is supplied to a fixed one of the transmission blocks 25, as seen in FIG. 5, the rotation in the third embodiment is carried out such that periodic signals to be supplied to transmission blocks may vary (i.e., each of the frequencies may be supplied to different transmission blocks). FIGS. 52A and 52B illustrate examples of the rotation of the switching operation of transmission conductors according to the third embodiment. The switching operation in FIG. 52B is different from that in FIG. 52A only in that the direction of rotation of the switching operation is reverse to that in the example of FIG. 52A. Therefore, description is given only of the example of FIG. 52A.

[0306] First, periodic signals of the frequencies f_0 to f_{15}, supplied from the multi-frequency signal supplying circuit 21, are supplied at the same time to those transmission conductors 14 which respectively have the highest index within their corresponding transmission blocks 25 (each including four transmission conductors 14), that is, to the transmission conductors Y_3, Y_7, ..., Y_{59}, Y_{63}, respectively. Then, while the periodic signals of the frequencies f_0 to f_{15} are supplied, the reception section 30 carries out position detection.

[0307] After a predetermined interval of time, the transmission conductors to which the frequencies f_0 to f_{15} are to be supplied are switched (or shifted) by one transmission conductor in a direction in which the index n decreases. In particular, the transmission conductors to which the frequencies f_0 to f_{15} are to be supplied are switched from the transmission conductors Y_3, Y_7, ..., Y_{55}, Y_{59} and Y_{63} selected in the preceding cycle to the transmission conductors Y_2, Y_6, ..., Y_{54}, Y_{58} and Y_{62}. Then, the periodic signals of the frequencies f_0 to f_{15} are supplied at the same time to the transmission conductors Y_2, Y_6, ..., Y_{54}, Y_{58} and Y_{62}. While the periodic signals of the frequencies f_0 to f_{15} are supplied, the reception section 30 carries out position detection. Such switching operation is repeated until the periodic signals of the frequencies f_0 to f_{15} are supplied to the transmission conductors Y_0, Y_4, ..., Y_{54}, Y_{58} and Y_{60} and the reception section 30 carries out position detection. Thereafter, the control circuit 40 controls the multi-frequency signal supplying circuit 21 to change the frequencies of the periodic signals to be supplied from the frequency production sections 24 of the multi-frequency signal supplying circuit 21 to the transmission blocks 25. In particular, the periodic signals of the frequencies f_0, f_1, ..., f_{13}, f_{14} and f_{15} supplied from the transmission blocks 25 are next supplied to the transmission conductors Y_{63}, Y_3, ..., Y_{51}, Y_{55} and Y_{59}, respectively. Then, position detection operation is carried out similarly as described above. Switching of the transmission conductors is carried out in this manner in the third embodiment.

[0308] With rotation of the switching operation of the transmission conductors 14 as in the present example, the following effect is achieved. In particular, in the examples illustrated in FIGS. 48, 49A and 49B in the second embodiment, since periodic signals of sixteen different frequencies are respectively supplied at the same time to 16 transmission conductors positioned adjacent to each other, position detection is carried out in a concentrated manner for a particular portion of the sensor section 10 at a certain point of time. However, for any portion other than the particular portion, position detection cannot be carried out. In contrast, in the third embodiment, periodic signals having different frequencies are respectively supplied to those transmission conductors, which are spaced apart from each other by a predetermined number of transmission conductors (in the present example, by three transmission conductors), across the entire set of transmission conductors (in the present example, 64 transmission conductors) (as in the first embodiment). Further, the transmission conductors to which the periodic signals having different frequencies are to be supplied are successively shifted or displaced with respect to the entire set of transmission conductors (i.e., each frequency signal is successively supplied to each of the entire set of transmission conductors). As a result, since the periodic signals of the different frequencies are supplied to every third transmission conductor, the position of a pointer can be detected in a well-balanced manner over the entire sensor section 10.

[0309] A rotation of the switching operation similar to that described above with respect to the transmission conductors 14 may be applied with respect to the reception conductors 12. Specifically, in the reception section, outputs from those of the reception conductors, which are spaced apart by a predetermined number of reception conductors (such as seven reception conductors) among the complete set of reception conductors (such as 128 reception conductors) may be detected. Then, these reception conductors for output detection are successively shifted or displaced among the complete set of transmission conductors similarly as in the rotation of the switching operation of the transmission conductors 14. With this configuration, an effect similar to that of the transmission section, as described above, can be achieved.

[0310] In all of the embodiments described above, including the examples of FIG. 6 (the first embodiment), FIGS.49A, 49B (the second embodiment), FIGS. 53A, 53B (Modification 1 to the second embodiment), and FIGS. 52A, 52B (the third embodiment), signals of different frequencies produced by the multi-frequency signal production circuit are supplied to predetermined ones of a plurality of transmission conductors 14, between which a predetermined number P (P is an integer which satisfies P ≥ 0) of transmission conductors are interposed, and such predetermined conductors are successively switched.

[0311] Further, predetermined ones of a plurality of reception conductors 12 between which a predetermined number R (R is an integer which satisfies R ≥ 0) are interposed are selected, and the predetermined conductors are successively switched.

<4. Fourth Embodiment>

[0312] A fourth embodiment of the present invention is configured to suppress a composite amplitude or beat phenomenon, where a plurality of periodic signals of different frequencies are supplied in a superposed relationship to a signal detection circuit according to the first to third embodiments.

[0313] It is assumed in the first to third embodiments that the initial phases of a plurality of periodic signals of different frequencies to be supplied at the same time to the transmission conductors are adjusted (or set) to 0 degree. Since the reception section 30 receives a plurality of periodic signals of different frequencies as a composite signal of the periodic signals, significant beats may be produced from the periodic signals. As a result, there is a possibility that the periodic signals may exceed the dynamic range of the reception section 30, causing saturation in the reception section 30. Further, if the level of the detected output signal is adjusted so as not to cause saturation in the reception section 30, there is the possibility that a desired detection sensitivity may not be obtained.

[0314] Therefore, in the fourth embodiment, the pointer detection apparatus includes phase controlling means for controlling the phase of periodic signals to be output from the multi-frequency signal production section, so that transmission starting phases of a plurality of periodic signals are dispersed to thereby suppress beats.

[0315] FIG. 54 shows a general configuration of the pointer detection apparatus according to the fourth embodiment. Referring to FIG. 54, the pointer detection apparatus 200 includes, as principal components thereof, a sensor section 10, a transmission section 210, a reception section 30, a position calculation circuit 35, and a control circuit 40 for controlling operation of the transmission section 210 and the reception section 30. In FIG. 54, elements like those of the pointer detection apparatus 100 described above with reference to FIG. 1 are denoted by like reference characters and overlapping description of them is omitted herein to avoid redundancy.

[0316] The transmission section 210 includes a phase controlling circuit 211, a multi-frequency signal supplying circuit 21, a transmission conductor selection circuit 22 and a clock generation circuit 23. The multi-frequency signal supplying circuit 21, transmission conductor selection circuit 22 and clock generation circuit 23 have a configuration similar to that in the first embodiment.

[0317] The phase controlling circuit 211 changes the phases of periodic signals produced by the multi-frequency signal supplying circuit 21 and supplies the periodic signals of the changed phases to the transmission conductors 14. For example, the phase controlling circuit 211 can set initial phases used in the periodic signal production sections 24 in the multi-frequency signal supplying circuit 21 of FIG. 4. In particular, the multi-frequency signal supplying circuit 21 of the pointer detection apparatus 100 of FIG. 1 controls the values of the initial phases to be provided to the periodic signal production sections 24 to carry out a phase adjustment process The control circuit 40 controls a degree by which the phase controlling circuit 211 shifts the phase of any periodic signal.

[0318] In the following, phase control over the transmission starting phases is described in connection with an example which involves two frequencies.

[0319] FIG. 55 illustrates waveforms of a periodic signal of a frequency f_0 and another periodic signal of another frequency f_1 where the transmission starting phase of the periodic signal of the frequency f_1 is displaced from that of the frequency signal of the frequency f_0 so that the transmission starting phases are dispersed. In the present example, adjacent periodic signals have opposite phases. In this manner, multiple periodic signals having different frequencies should be combined such that their transmission starting phases are displaced from each other and, further, adjacent periodic signals have opposite phases. As a result, the periodic signals cancel each other at a rising edge or a falling edge of waveforms upon starting of transmission or upon ending of transmission, to thereby prevent an excessively high output signal (due to beat, for example) from flowing into the reception section 30.

[0320] While the present example described involves two frequencies for the convenience of description, the number of frequencies is not limited to two, but may be greater than two. A dispersion of transmission starting phases in the case of a plurality of frequencies is hereinafter described. Where the number of frequencies is an odd number, the transmission starting phase of the frequency, which is left out after the rest of the frequencies are combined into one or more pairs, should be set to 0 degree or 180 degrees.

[0321] The method of the phase control is not limited to the example described above. For example, the phase controlling circuit 211 may be configured from 16 phase shifters (not shown) in a corresponding relationship to the periodic signal production sections 24, respectively, in the multi-frequency signal supplying circuit 21 of FIG. 3. Alternatively, the phase controlling circuit 211 may include 45-degree phase shifting circuits, signal inversion circuits, or switches (not shown), so as to selectively control the number of phase shifts by the phase shifting circuits or the phase inversion by the signal inversion circuits to thereby carry out a phase control by 45 degrees or by 90 degrees.

[0322] In the following, modes of a plurality of transmission starting phases of different periodic signals are described.

[0323] FIGS. 56 to 61 illustrate composite waveforms of a plurality of periodic signals after a phase control is carried out where the initial phases of the periodic signals are varied in different patterns. In these examples, 16 periodic signals of different frequencies from 100 kHz to 250 kHz are generated by the multi-frequency signal supplying circuit 21 in a corresponding relationship to the number of transmission blocks, that is, 16, and the reception period by the reception section 30 is 200 μs.

[0324] FIG. 56 illustrates an example of a composite waveform of 16 periodic signals of different frequencies where no phase dispersion is applied (refer to Table 1 below). In other words, FIG. 56 illustrates the composite waveform where 16 periodic signals of wavelengths from 100 kHz to 250 kHz are supplied without carrying out any phase control.

[Table 1]

Phase dispersion: No		
Transmission Block No.	Frequency [kHz]	Phase [degrees]
1	100	0
2	110	0
3	120	0
4	130	0
5	140	0
6	150	0
7	160	0
8	170	0
9	180	0
10	190	0
11	200	0
12	210	0
13	220	0
14	230	0
15	240	0
16	250	0

Reception period: 200 μs

[0325] FIG. 57 illustrates an example of a composite waveform where phase dispersion is applied for every 90 degrees to 16 periodic signals of different frequencies (pattern 0: refer to Table 2 below). Referring to FIG. 57, in the example illustrated, 90-degree phase shifting is applied to achieve phase dispersion.

[Table 2]

Phase dispersion: pattern 0 (for every 90 degrees)		
Transmission Block No.	Frequency [kHz]	Phase [degrees]
1	100	0
2	110	90
3	120	180
4	130	270
5	140	0
6	150	90
7	160	180
8	170	270
9	180	0
10	190	90
11	200	180
12	210	270
13	220	0
14	230	90
15	240	180
16	250	270

Reception period: 200 μs

[0326] FIG. 58 illustrates an example of a composite waveform where phase dispersion is applied for every ±90 degrees to 16 periodic signals of different frequencies (pattern 1: refer to Table 3 below). Referring to FIG. 58, in the example illustrated, 90-degree phase shifting and phase reversal are selectively applied to achieve phase dispersion.

[Table 3]

Phase dispersion: pattern 1 (for every ±90 degrees)		
Transmission Block No.	Frequency [kHz]	Phase [degrees]
1	100	0
2	110	180
3	120	90
4	130	270
5	140	0
6	150	180
7	160	90
8	170	270
9	180	0
10	190	180
11	200	90
12	210	270

(continued)

Phase dispersion: pattern 1 (for every ±90 degrees)		
Transmission Block No.	Frequency [kHz]	Phase [degrees]
13	220	0
14	230	180
15	240	90
16	250	270

Reception period: 200 μs

[0327] FIG. 59 illustrates an example of a composite waveform where phase dispersion is applied for every ±45 degrees to 16 periodic signals of different frequencies (pattern 2-1: refer to Table 4 below). Referring to FIG. 59, in the example illustrated, 45-degree phase shifting and phase reversal are selectively applied to achieve phase dispersion.

[Table 4]

Phase dispersion: pattern 2-1 (for every ±45 degrees)		
Transmission Block No.	Frequency [kHz]	Phase [degrees]
1	100	0
2	110	180
3	120	45
4	130	315
5	140	90
6	150	270
7	160	135
8	170	225
9	180	0
10	190	180
11	200	45
12	210	315
13	220	90
14	230	270
15	240	135
16	250	225

Reception period: 200 μs

[0328] FIG. 60 illustrates an example of a composite waveform where phase dispersion is applied for every ±45 degrees to 16 periodic signals of different frequencies (pattern 2-2: refer to Table 5 below). Referring to FIG. 60, in the example illustrated, 45-degree phase shifting and phase reversal are selectively applied to the periodic signals to be supplied to the first (1^{st}) to eighth (8^{th}) transmission blocks. Further, 45-degree phase shifting and phase reversal are selectively applied to the periodic signals to be supplied to the ninth (9^{th}) to sixteenth (16^{th}) transmission blocks, such that the resulting phase dispersion pattern forms mirror images on both sides of the boundary between the eighth (8^{th}) and ninth (9^{th}) transmission blocks.

[Table 5]

Phase dispersion: pattern 2-2 (for every ±45 degrees, upwardly and downwardly symmetrical; mirror images)		
Transmission Block No.	Frequency [kHz]	Phase [degrees]
1	100	0
2	110	180
3	120	45
4	130	315
5	140	90
6	150	270
7	160	135
8	170	225
9	180	225
10	190	135
11	200	270
12	210	90
13	220	315
14	230	45
15	240	180
16	250	0

Reception period: 200 μs

[0329] FIG. 61 illustrates an example of a composite waveform where phase dispersion is applied for every ±22.5 degrees to 16 periodic signals of different frequencies (pattern 3: refer to Table 6 below). Referring to FIG. 61, 22.5-degree phase shifting and phase reversal are selectively applied to achieve phase dispersion.

[Table 6]

Phase dispersion: pattern 3 (for every ±22.5 degrees)		
Transmission Block No.	Frequency [kHz]	Phase [degrees]
1	100	0
2	110	180.0
3	120	22.5
4	130	337.5
5	140	45.0
6	150	315.0
7	160	67.5
8	170	292.5
9	180	90.0
10	190	270.0
11	200	112.5
12	210	247.5

(continued)

Phase dispersion: pattern 3 (for every ±22.5 degrees)		
Transmission Block No.	Frequency [kHz]	Phase [degrees]
13	220	135.0
14	230	225.0
15	240	157.5
16	250	202.5

Reception period: 200 μs

[0330] Resulting characteristics of the composite waveforms having the phase dispersion patterns illustrated in FIGS. 56 to 61 are summarized below:

Pattern	Phase dispersion method	Resulting characteristics
Phase dispersion (No)	Phase dispersion: No	High beat
Phase dispersion (0)	Phase dispersion: for every 90 degrees	No effect
Phase dispersion (1)	Phase dispersion: for every ±90 degrees	Medium beat
Phase dispersion (2-1)	Phase dispersion: for every ±45 degrees	Medium beat
Phase dispersion (2-2)	Phase dispersion: ±45 degrees (upwardly and downwardly symmetrical; mirror images)	Low beat
Phase dispersion (3)	Phase dispersion: ±22.5 degrees	Medium beat

[0331] Based on the composite waveforms having the phase dispersion patterns, it can be recognized that, even if phase dispersion is applied for every 90 degrees as in the case of pattern (0), the beat of the composite waveform does not decrease. On the other hand, where the phase dispersion is applied for every ±90 degrees, as in the case of the composite waveforms having patterns (1) to (3), the beat of the composite waveform decreases. In other words, both phase shifting and phase reversal should be selectively applied to achieve phase dispersion. Among the composite waveforms measured, the beat suppression effect of pattern (2-2) is the highest. In pattern (2-2), the phase dispersion patterns of the first half (Block Nos. 1 to 8) and the latter half (Block No. 9 to 16) of the entire set of transmission blocks (16 transmission blocks, each block including 1 transmission conductor in the present example) are inverted relative to each other, such that no phase dispersion pattern is repeated between the first half and the latter half of the transmission blocks (i.e., of the transmission conductors). In contrast, patterns (1) and (2-1) respectively include four and two repeating patterns within the first (1^{st}) to the sixteenth (16^{th}) transmission blocks. Pattern (3) includes no repeating pattern. However, pattern (3) includes a relatively greater number of small phase differences between successive transmission blocks (i.e., between successive transmission conductors in this example). Accordingly, it is proposed that the deviation in phase differences between transmission conductors, whose outputs are combined, should be as great as possible, in addition to that the entire set of transmission conductors (in the present example, 16 transmission conductors) should have a pattern including little or no repeating initial phases.

[0332] In the present example, since the pointer detection apparatus is configured such that transmission starting phases of a plurality of periodic signals of different frequencies are dispersed, upon starting or ending of transmission, transient current on the reception side does not become excessive and beats can be diminished. Consequently, an output signal detected by the reception section 30 does not exceed the dynamic range of the reception section 30, and saturation of the reception section 30 is prevented. Therefore, the degree of freedom in setting the reception gain of an amplification circuit increases, and a high detection sensitivity can be obtained.

[0333] In the first to fourth embodiments described above, at least a reception conductor group is divided into a plurality of detection blocks. However, the pointer detection apparatus may also be configured such that a reception conductor group is not divided, but detection circuits connected to all reception conductors are processed in parallel such that output signals of all reception conductors are detected at the same time.

[0334] Since the embodiments described above are particular examples of a preferred mode for carrying out the present invention, various technically preferable restrictions are included. However, the present invention is not limited to these embodiments unless otherwise specified so as to restrict the present invention to the description of the embodiments. Further, the used materials, the processing time, processing order, numerical value conditions of the parameters and so forth specified in the foregoing description are merely preferred examples, and also the dimensions, shapes, disposition relationships and so forth in the accompanying drawings referred to in the foregoing description represent merely practical examples of the embodiments. Accordingly, the present invention shall not be restricted to the examples of the embodiments described above and allows various modifications and alterations without departing from the spirit and scope of the present invention.

[0335] For example, while the series of processes carried out by the pointer detection apparatus described above is executed by hardware, it may otherwise be executed by software. Naturally, the processes can be implemented also by a combination of hardware and software. Where the processes are executed by software, a program which forms the software is installed from a computer-readable (or program recording) tangible medium into a special-purpose computer (processor) including hardware for receiving the software, or into a general-purpose computer (processor) which can execute various functions when various programs are installed therein.

[0336] Further, in the present specification, the processing steps which describe the program stored in a computer-readable medium may be, but need not necessarily be, processed in a time sequence in the order as described. Still further, these processing steps may be executed in parallel or individually (discretely), without being processed in a time sequence (e.g., parallel processing or processing by objects).

Claims

1. A pointer detection apparatus, comprising:

   a conductor pattern including a plurality of first conductors disposed in a first direction and a plurality of second conductors disposed in a second direction which crosses the first direction;
   a multi-frequency signal production circuit configured to produce a plurality of signals of different frequencies;
   a phase controlling circuit configured to control initial phases of the plurality of signals of different frequencies produced by the multi-frequency signal production circuit;
   a first conductor selection circuit configured to selectively supply said signals of different frequencies produced by said multi-frequency signal production circuit to those first conductors, between which N number of the first conductors are interposed, N being an integer equal to or greater than 0;
   a second conductor selection circuit configured to selectively receive detection signals from the plurality of second conductors; and
   a signal detection circuit configured to detect signals of individual frequencies, corresponding to the signals of different frequencies produced by said multi-frequency signal production circuit, which are representative of coupling states at cross points between the first conductors and the second conductors, and are received from said second conductor selection circuit.

2. The pointer detection apparatus according to claim 1, wherein said first conductor selection circuit is further configured to divide the plurality of first conductors into a plurality of groups each including M conductors, M being an integer equal to or greater than 2, to supply a signal of each of the different frequencies produced by said multi-frequency signal production circuit to one of the M conductors included in each group.

3. The pointer detection apparatus according to claim 2, wherein said first conductor selection circuit is further configured to successively supply signals of each of the different frequencies to the M conductors within each group.

4. The pointer detection apparatus according to claim 1, wherein said first conductor selection circuit is further configured to divide the plurality of first conductors into a plurality of groups, each group including Q number of the first conductors, Q being an integer equal to or greater than 2, and the first conductor selection circuit being further configured to select one group among the plurality of groups and to supply said signals of different frequencies produced by said multi-frequency signal production circuit to those first conductors in the selected group.

5. The pointer detection apparatus according to claim 4, wherein said first conductor selection circuit is further configured to successively switch the selected group among the plurality of groups, to which the signals of different frequencies are supplied.

6. The pointer detection apparatus according to claim 1, wherein said phase controlling circuit is further configured to apply a phase dispersion pattern to the initial phases of the plurality of signals of different frequencies at every ± 90 degrees.

7. The pointer detection apparatus according to claim 1, wherein said phase controlling circuit is further configured to apply a phase dispersion pattern to the initial phases of the plurality of signals of different frequencies at every ±45 degrees.

8. The pointer detection apparatus according to claim 1, wherein said phase controlling circuit is further configured to apply a phase dispersion pattern to the initial phases of the plurality of signals of different frequencies at every ±22.5 degrees.

9. The pointer detection apparatus according to claim 1, wherein said phase controlling circuit is further configured to apply a phase dispersion pattern having mirror images to the initial phases of the plurality of signals of different frequencies.

10. The pointer detection apparatus according to claim 1, wherein said conductor pattern including the plurality of first conductors disposed in the first direction and the plurality of second conductors disposed in the second direction is disposed on one surface of a substrate,
wherein an insulating member is disposed in a region in which the plurality of first conductors and the plurality of second conductors cross each other in order to electrically isolate the plurality of first conductors from the plurality of second conductors; and
wherein each of the plurality of first conductors disposed in the first direction is formed in a pattern of a plurality of land shapes electrically connected to each other, while each of the plurality of second conductors disposed in the second direction is formed in a pattern of a line shape, such that a signal is supplied to the pattern of the land shapes while a detection signal is received from the pattern of the line shape.

11. The pointer detection apparatus according to claim 1, wherein the plurality of first conductors disposed in the first direction are disposed on one surface of a substrate while the plurality of second conductors disposed in the second direction are disposed on the other surface of said substrate; and
each of the plurality of first conductors disposed in the first direction is formed in a pattern of a plurality of land shapes electrically connected to each other, while each of the plurality of second conductors disposed in the second direction is formed in a pattern of a line shape, such that a signal is supplied to the pattern of the land shapes while a detection signal is received from the pattern of the line shape.

12. The pointer detection apparatus according to claim 1, wherein the first direction is a circumferential direction such that the plurality of first conductors are disposed concentrically with respect to a predetermined central point, and the second direction is a radial direction along which each of the second conductors having a line shape extends from the central point.

13. The pointer detection apparatus according to claim 1, wherein a state in which a pointer spaced from said conductor pattern is identified based on both a maximum value and a shape characteristic of the signals detected by said signal detection circuit.

14. The pointer detection apparatus according to claim 1, wherein the pressure of a pointer to said conductor pattern is detected based on a spatial distribution of the levels of the signals of individual frequencies detected by said signal detection circuit.

15. The pointer detection apparatus according to claim 1, further comprising:

a position calculation circuit configured to calculate a position of a pointer on said conductor pattern based on the signals of individual frequencies detected by said signal detection circuit.

FIG. 1

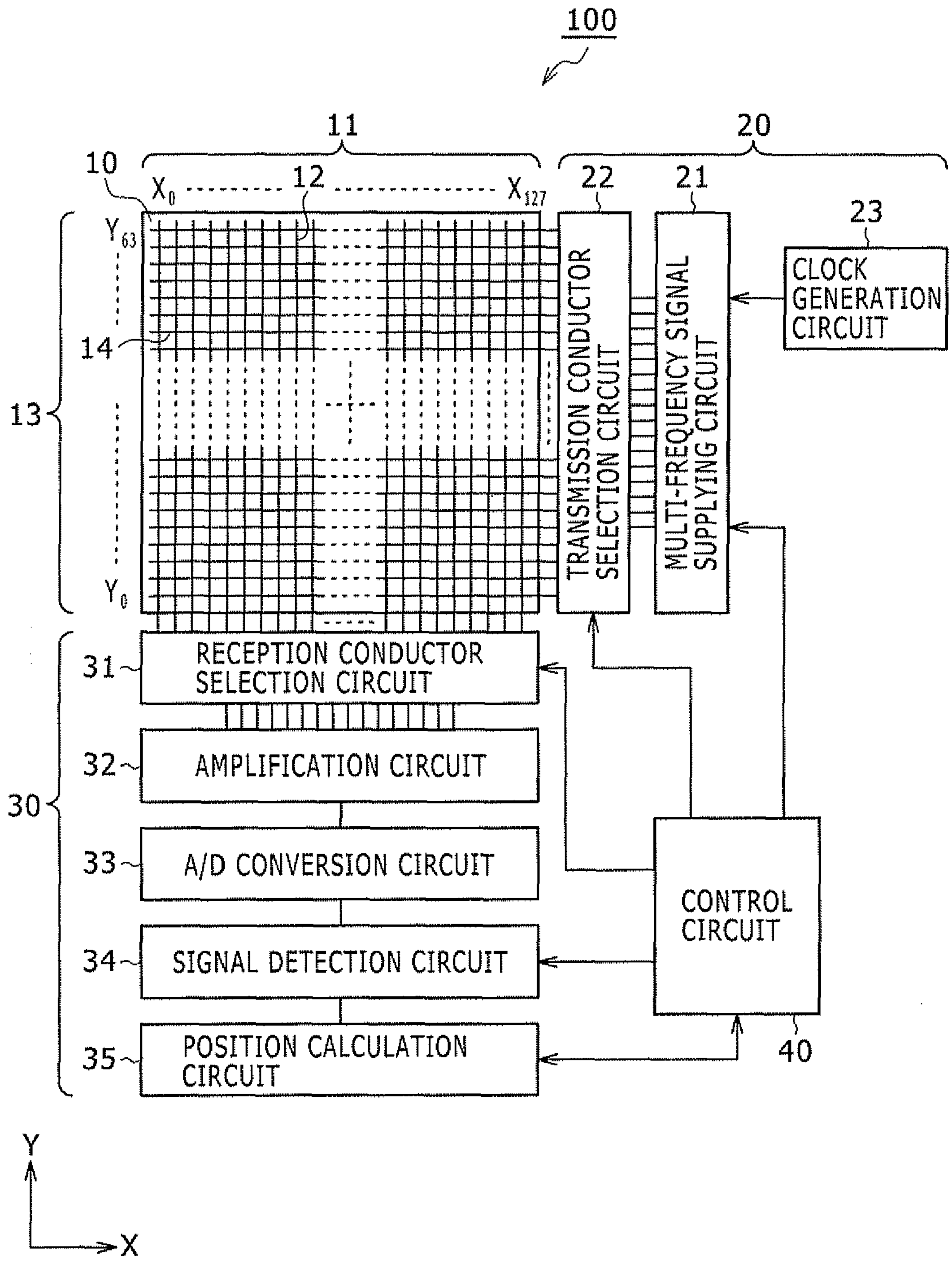

100
11
20
10
X_0
12
X_{127}
22
21
23
Y_{63}
14
13
Y_0
TRANSMISSION CONDUCTOR SELECTION CIRCUIT
MULTI-FREQUENCY SIGNAL SUPPLYING CIRCUIT
CLOCK GENERATION CIRCUIT
31
RECEPTION CONDUCTOR SELECTION CIRCUIT
32
AMPLIFICATION CIRCUIT
30
33
A/D CONVERSION CIRCUIT
CONTROL CIRCUIT
34
SIGNAL DETECTION CIRCUIT
35
POSITION CALCULATION CIRCUIT
40
Y
X

FIG. 2

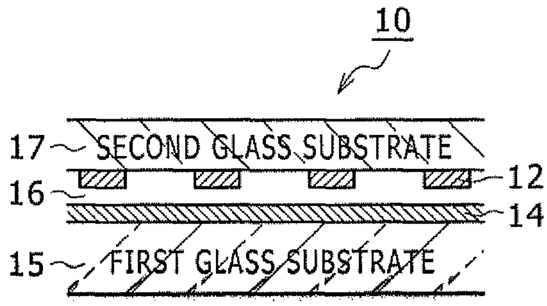

10
17
SECOND GLASS SUBSTRATE
12
16
14
15
FIRST GLASS SUBSTRATE

FIG. 3

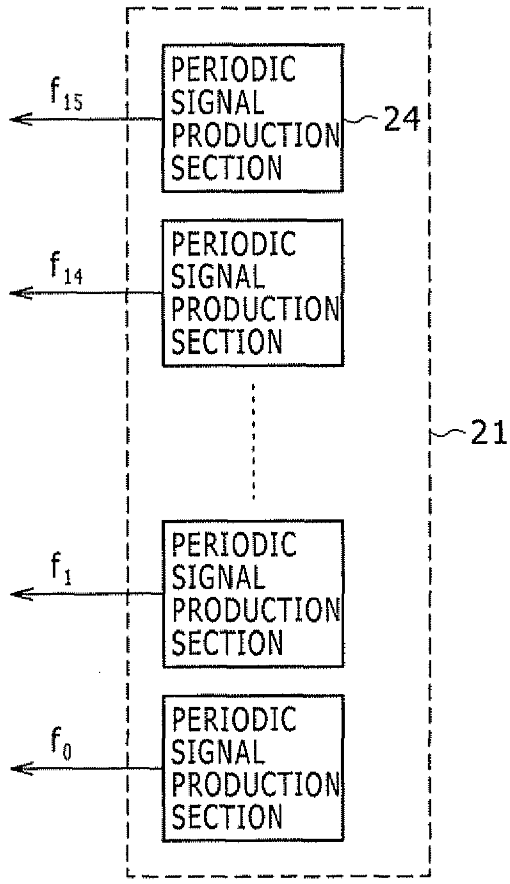

f_{15}
PERIODIC SIGNAL PRODUCTION SECTION
24
f_{14}
PERIODIC SIGNAL PRODUCTION SECTION
21
f_1
PERIODIC SIGNAL PRODUCTION SECTION
f_0
PERIODIC SIGNAL PRODUCTION SECTION

FIG. 4

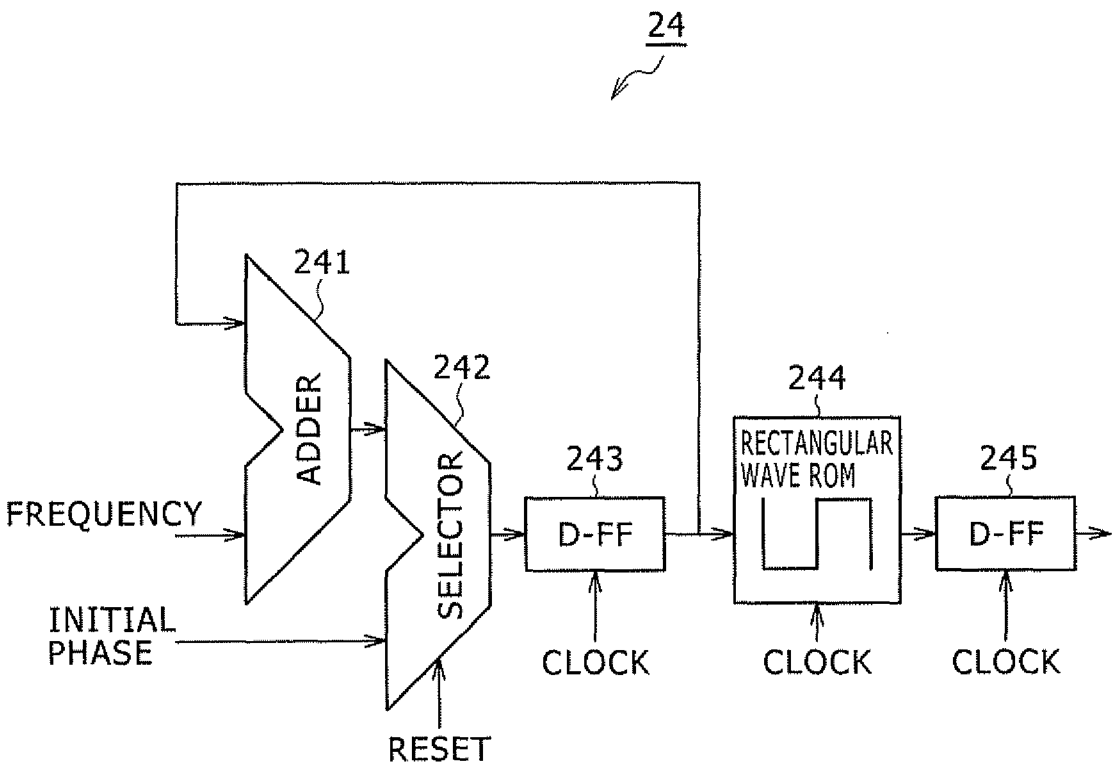

24
241
ADDER
242
SELECTOR
243
D-FF
244
RECTANGULAR WAVE ROM
245
D-FF
FREQUENCY
INITIAL PHASE
RESET
CLOCK
CLOCK
CLOCK

FIG. 5

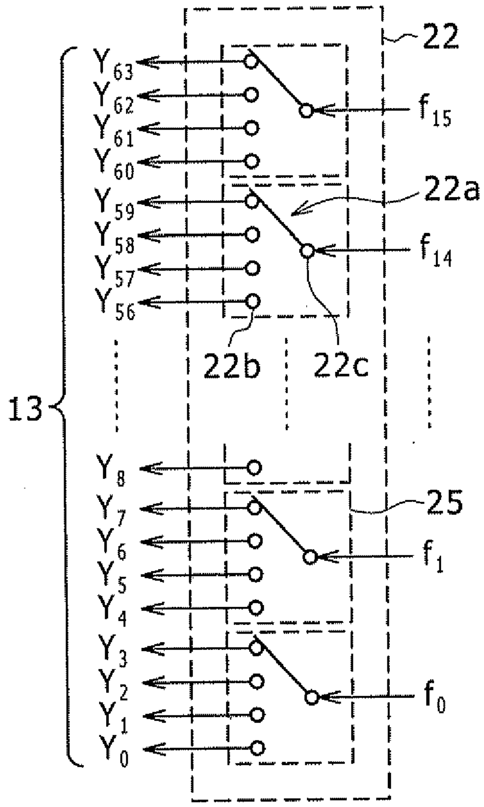

22
Y63
Y62
Y61
Y60
f15
22a
Y59
Y58
Y57
Y56
f14
22b
22c
13
Y8
25
Y7
Y6
Y5
Y4
f1
Y3
Y2
Y1
Y0
f0

FIG. 6

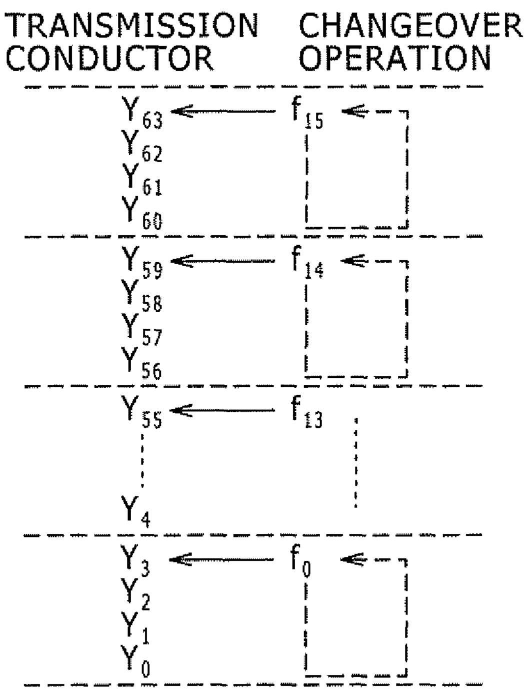

TRANSMISSION CONDUCTOR
CHANGEOVER OPERATION
Y63
Y62
Y61
Y60
f15
Y59
Y58
Y57
Y56
f14
Y55
f13
Y4
Y3
Y2
Y1
Y0
f0

FIG. 7

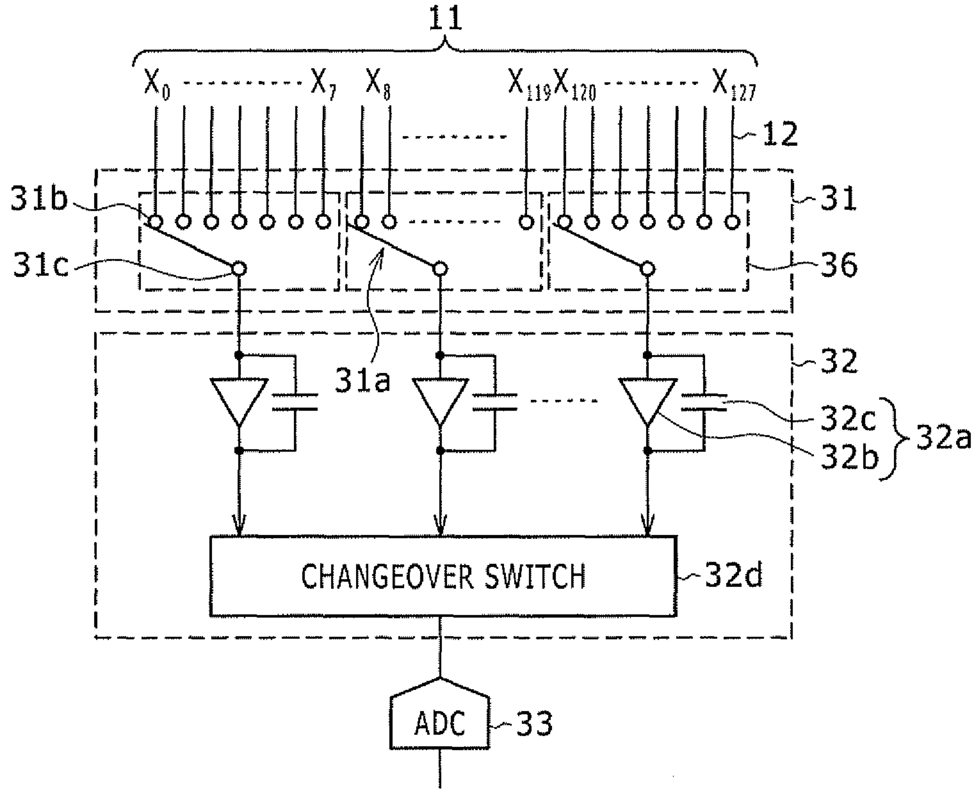

11
X0 X7 X8 X119 X120 X127
12
31b
31
31c
36
31a
32
32c
32b
32a
CHANGEOVER SWITCH
32d
ADC
33

FIG. 8

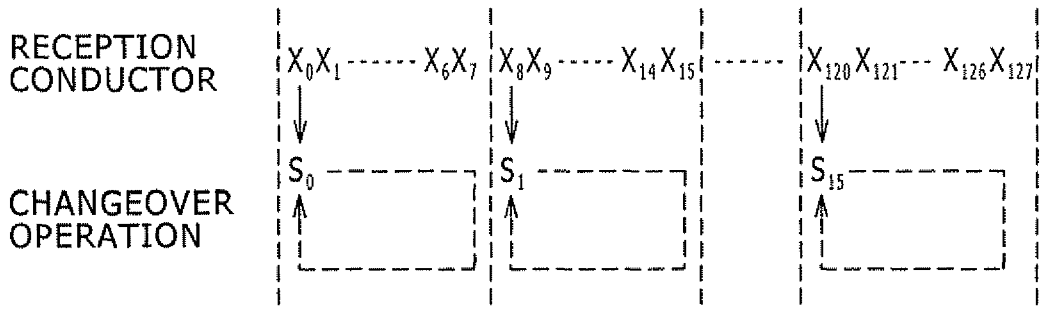

RECEPTION CONDUCTOR
X0 X1 X6 X7
X8 X9 X14 X15
X120 X121 X126 X127
CHANGEOVER OPERATION
S0
S1
S15

FIG.9

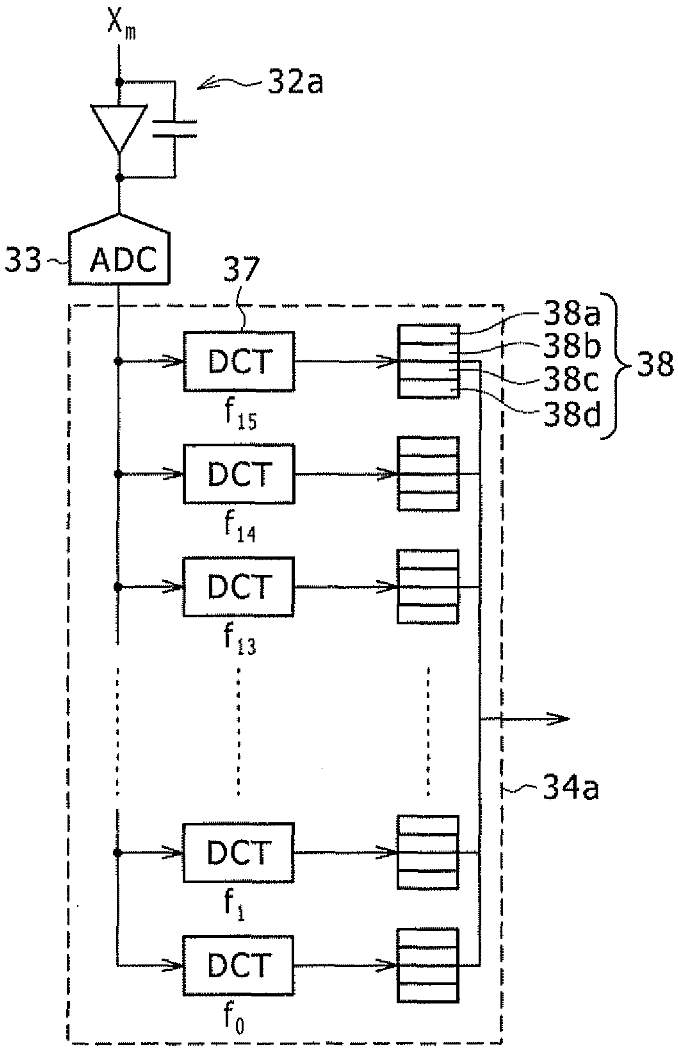

X_m
32a
33
ADC
37
DCT
f_{15}
38a
38b
38c
38d
38
DCT
f_{14}
DCT
f_{13}
34a
DCT
f_1
DCT
f_0

FIG.10

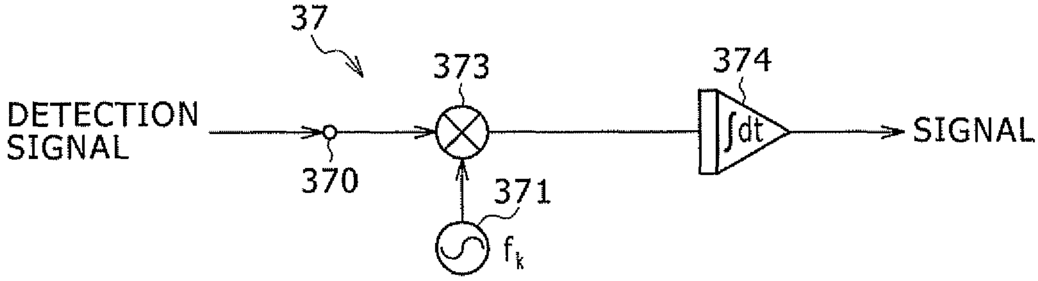

37
373
374
DETECTION SIGNAL
$\int dt$
SIGNAL
370
371
f_k

FIG.11A

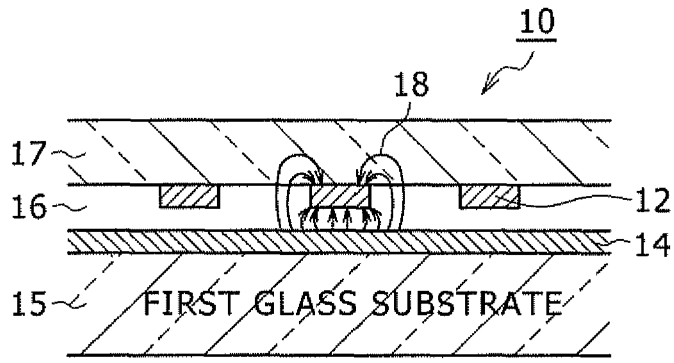


FIG.11B

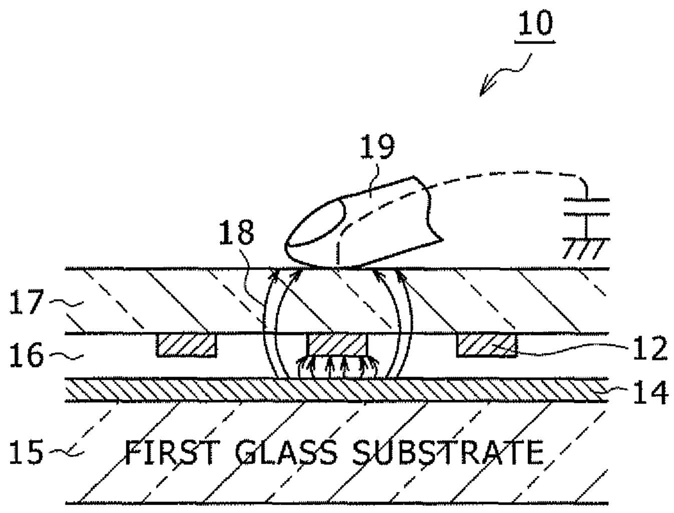


FIG.12A

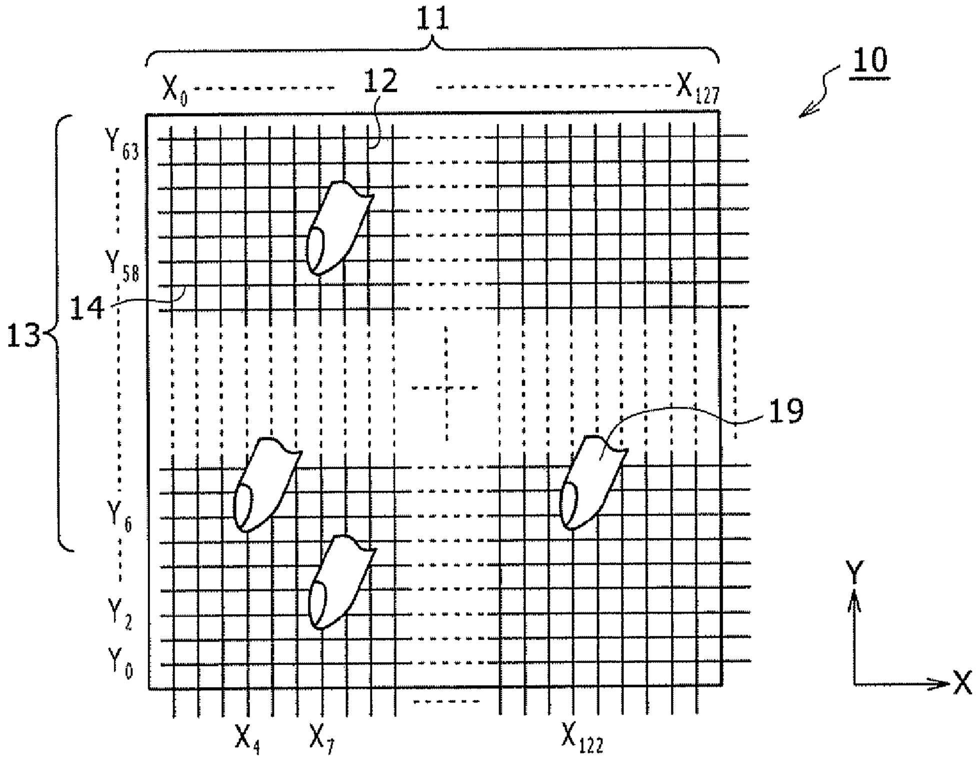


FIG.12B

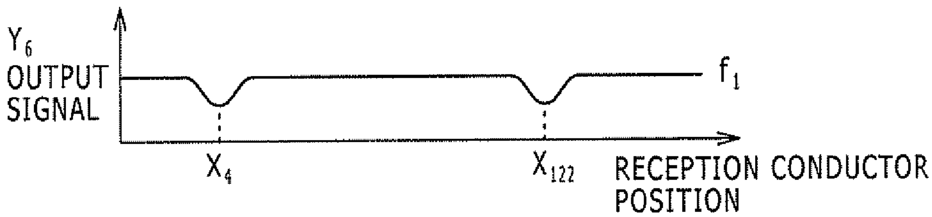


FIG.12C

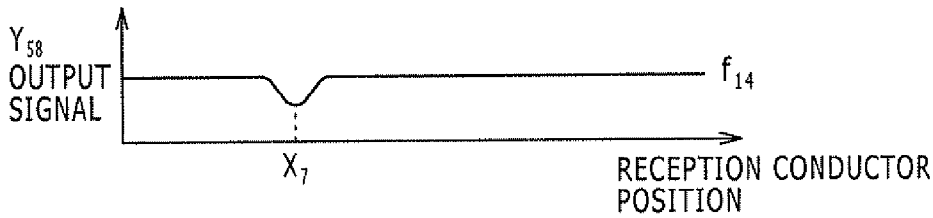


FIG.12D

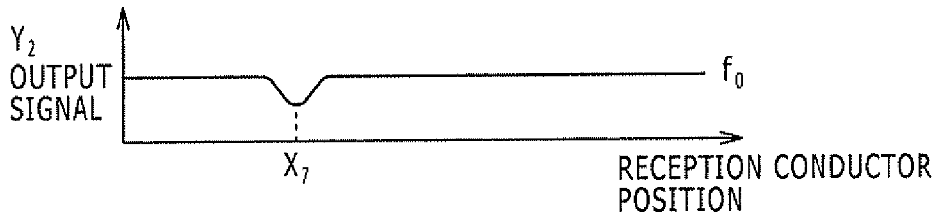


FIG.13

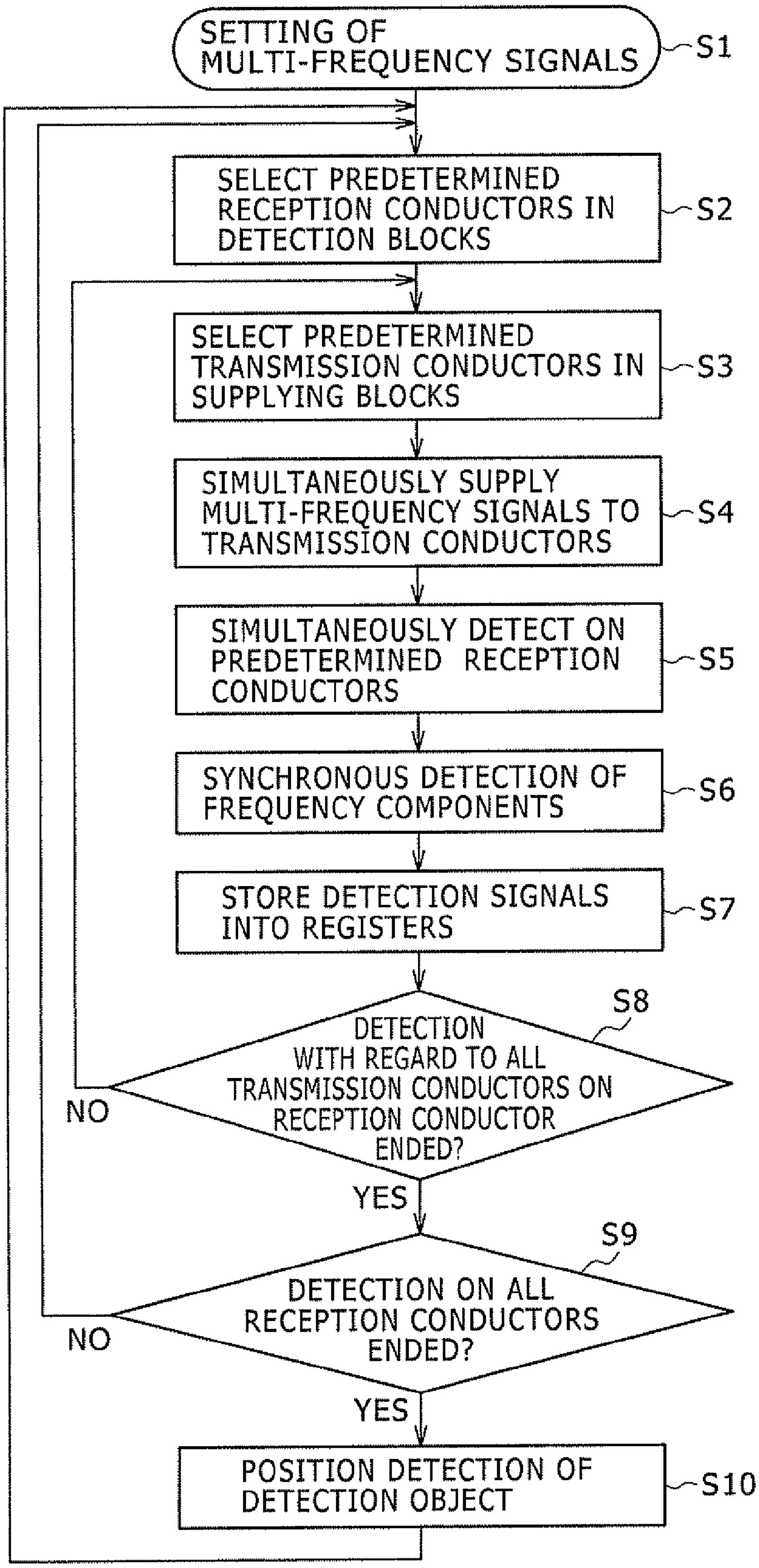

SETTING OF MULTI-FREQUENCY SIGNALS
S1
SELECT PREDETERMINED RECEPTION CONDUCTORS IN DETECTION BLOCKS
S2
SELECT PREDETERMINED TRANSMISSION CONDUCTORS IN SUPPLYING BLOCKS
S3
SIMULTANEOUSLY SUPPLY MULTI-FREQUENCY SIGNALS TO TRANSMISSION CONDUCTORS
S4
SIMULTANEOUSLY DETECT ON PREDETERMINED RECEPTION CONDUCTORS
S5
SYNCHRONOUS DETECTION OF FREQUENCY COMPONENTS
S6
STORE DETECTION SIGNALS INTO REGISTERS
S7
S8
DETECTION WITH REGARD TO ALL TRANSMISSION CONDUCTORS ON RECEPTION CONDUCTOR ENDED?
NO
YES
S9
DETECTION ON ALL RECEPTION CONDUCTORS ENDED?
NO
YES
POSITION DETECTION OF DETECTION OBJECT
S10

FIG.14

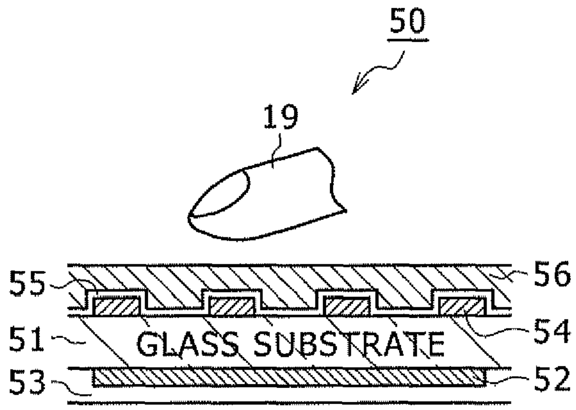


FIG.15A

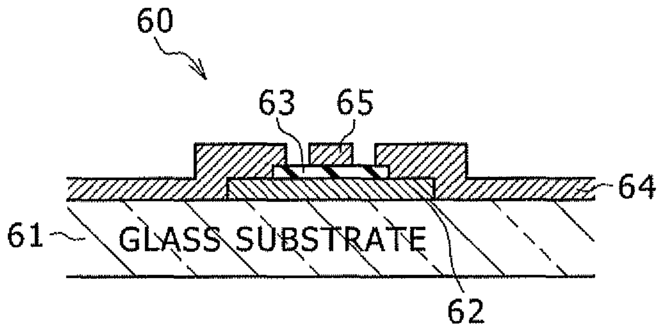


FIG.15B

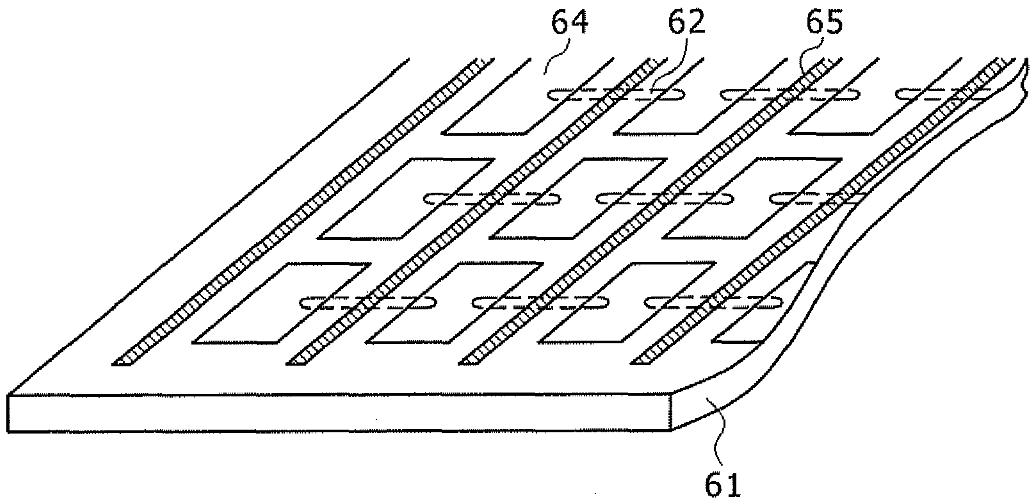


FIG.16A

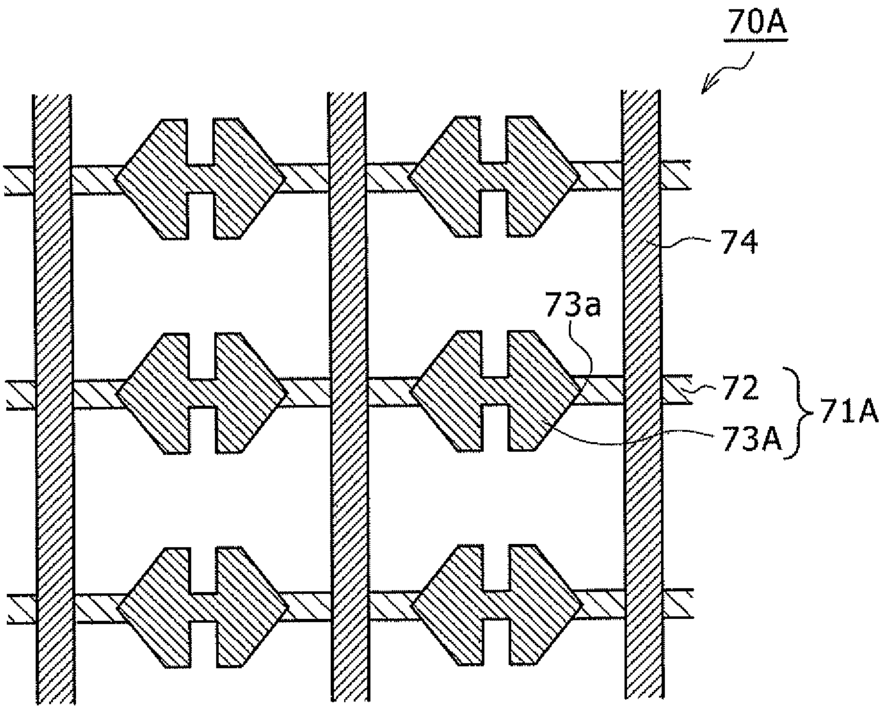


FIG.16B

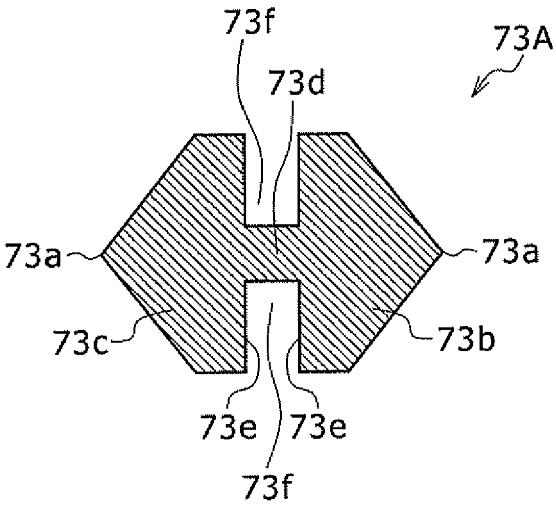


FIG.17

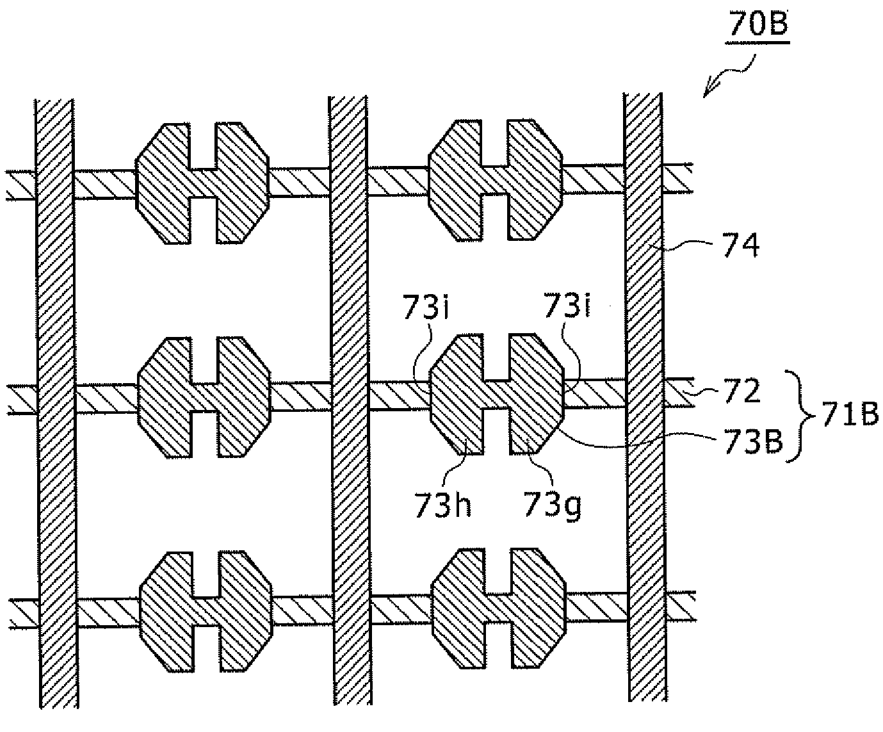


FIG.18

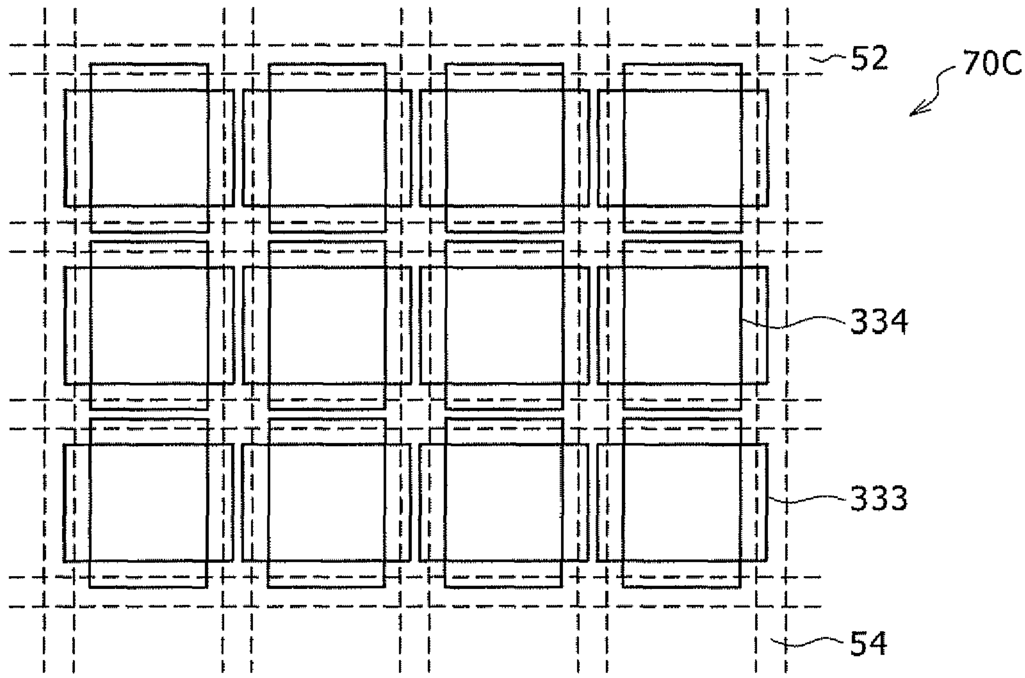


FIG.19A

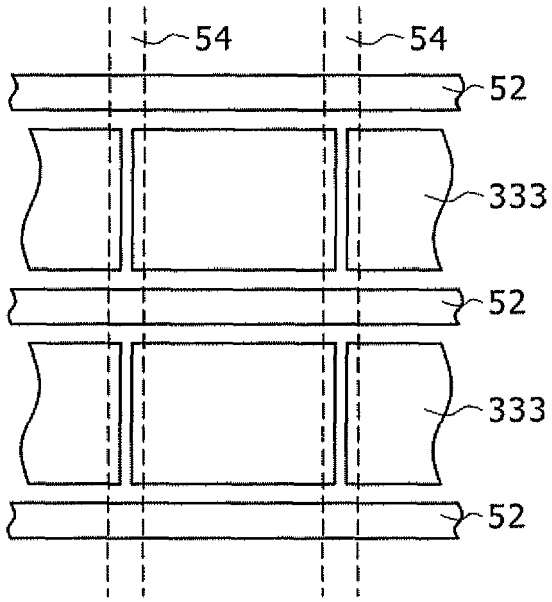


FIG.19B

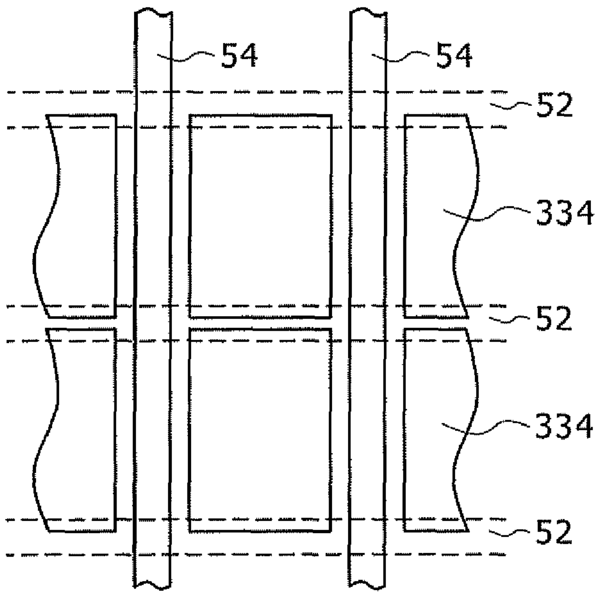


FIG.20

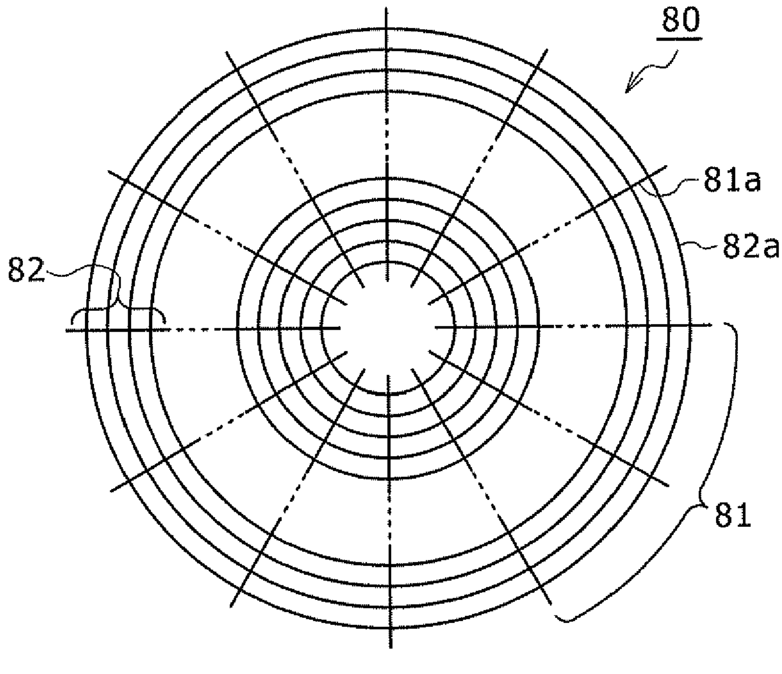


FIG.21A

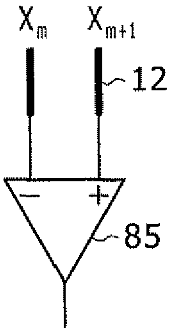


FIG.21B

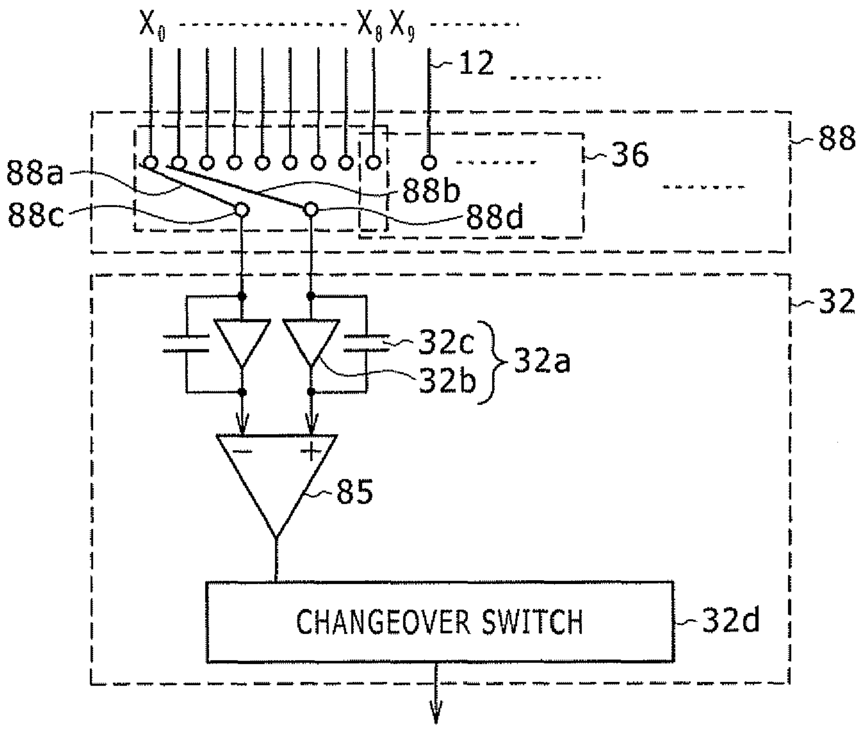


FIG.22

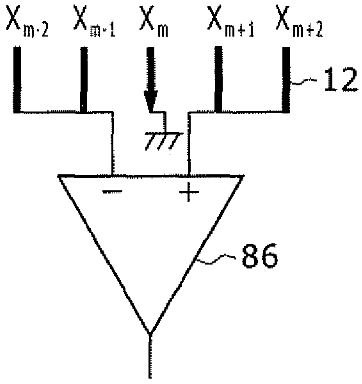


FIG.23

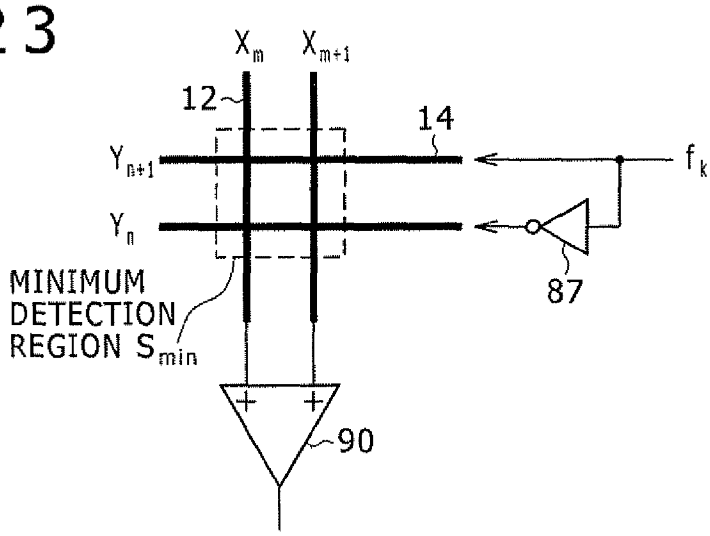


FIG.24

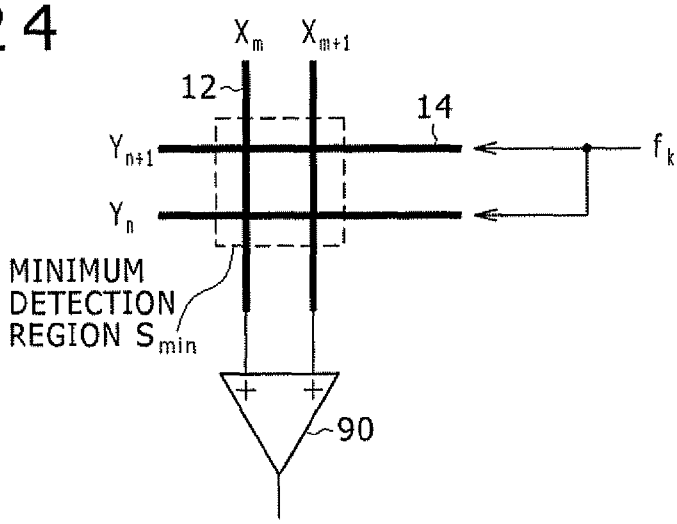


FIG.25A

$Y_3 \longleftarrow f_0$
$Y_2 \longleftarrow f_0$
Y_1
Y_0

FIG.25B

Y_3
Y_2
$Y_1 \longleftarrow f_0$
$Y_0 \longleftarrow f_0$

FIG.26A

$Y_3 \longleftarrow f_0$
$Y_2 \longleftarrow f_0$
Y_1
Y_0

FIG.26B

Y_3
$Y_2 \longleftarrow f_0$
$Y_1 \longleftarrow f_0$
Y_0

FIG.26C

Y_3
Y_2
$Y_1 \longleftarrow f_0$
$Y_0 \longleftarrow f_0$

FIG.27

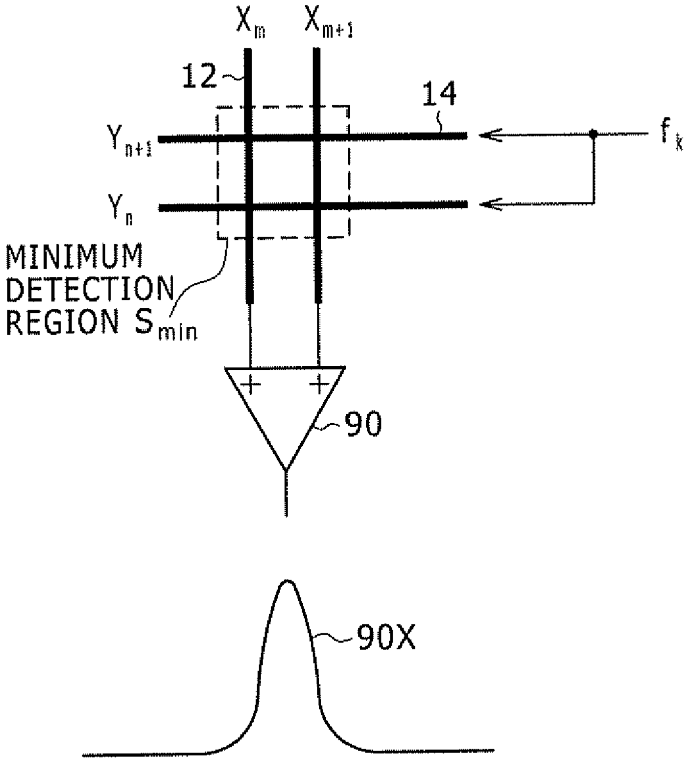
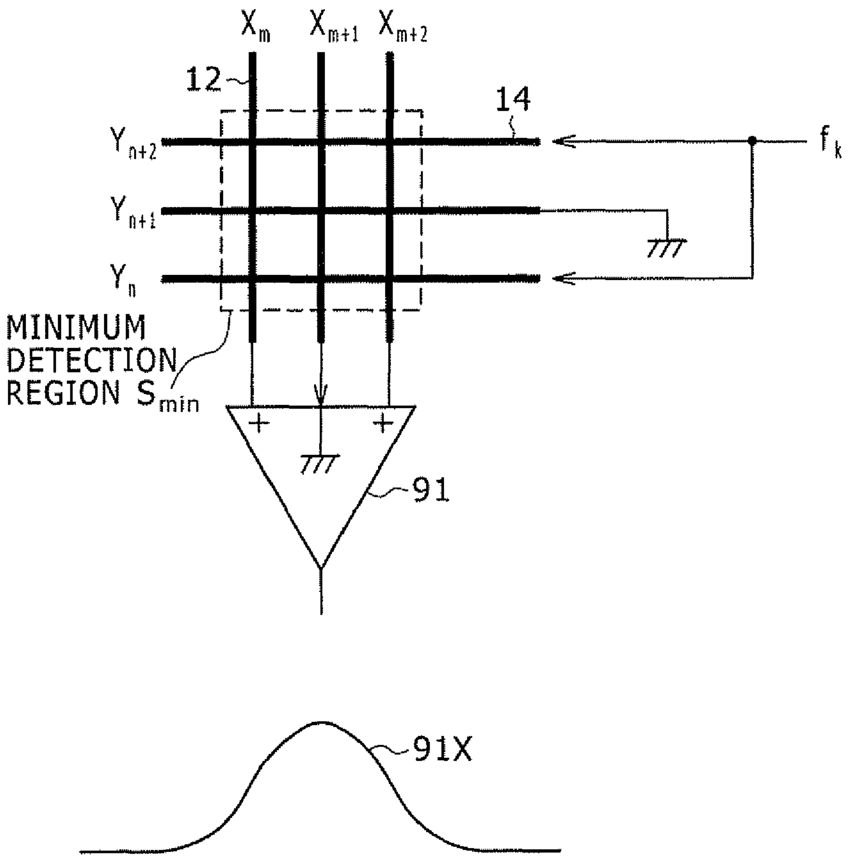


FIG.28



X_m
X_{m+1}
X_{m+2}
12
14
Y_{n+2}
Y_{n+1}
Y_n
f_k
MINIMUM DETECTION REGION S_{min}
+
+
91
91X

FIG.29

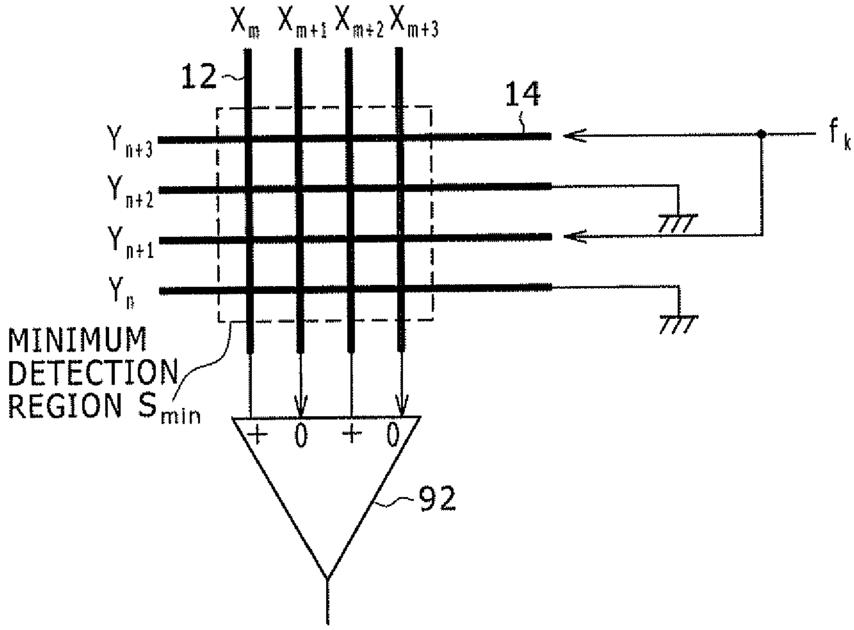
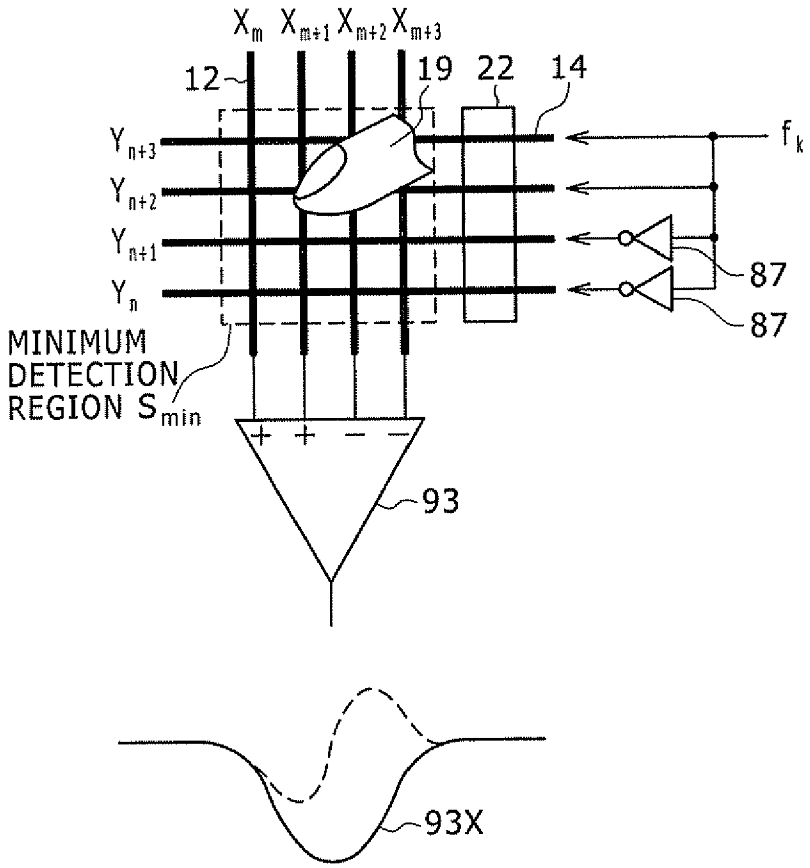

X_m
X_{m+1}
X_{m+2}
X_{m+3}
12
14
f_k
Y_{n+3}
Y_{n+2}
Y_{n+1}
Y_n
MINIMUM
DETECTION
REGION S_{min}
+
0
+
0
92

FIG.30



X_m X_{m+1} X_{m+2} X_{m+3}
12
19
22
14
f_k
Y_{n+3}
Y_{n+2}
Y_{n+1}
Y_n
87
87
MINIMUM
DETECTION
REGION S_{min}
+ + − −
93
93X

FIG.31

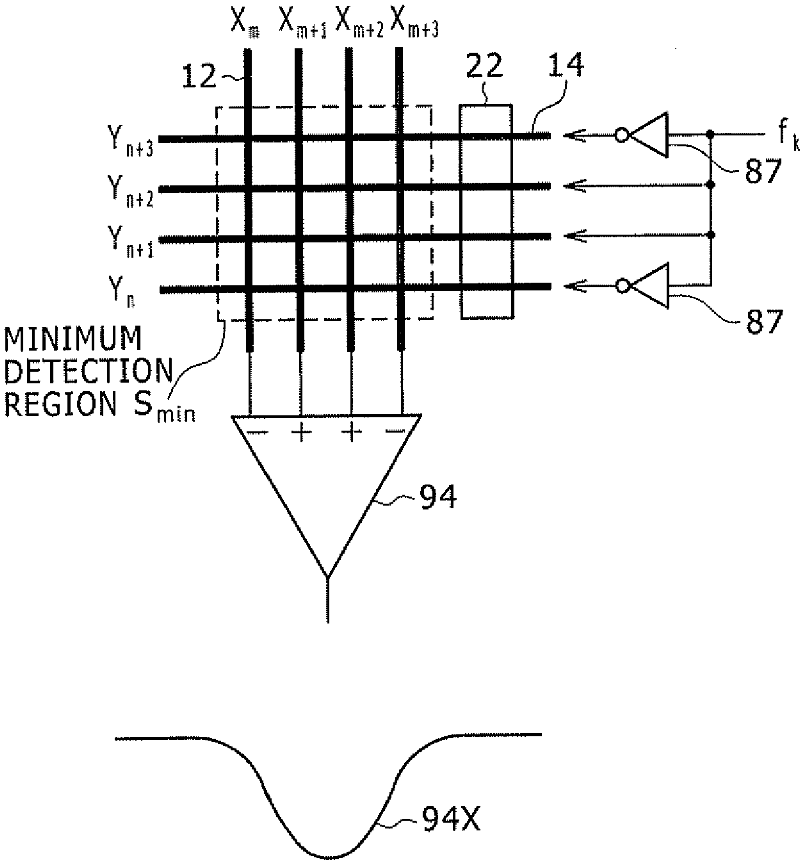

X_m X_{m+1} X_{m+2} X_{m+3}
12
22
14
Y_{n+3}
Y_{n+2}
Y_{n+1}
Y_n
f_k
87
87
MINIMUM DETECTION REGION S_{min}
94
94X

FIG.32

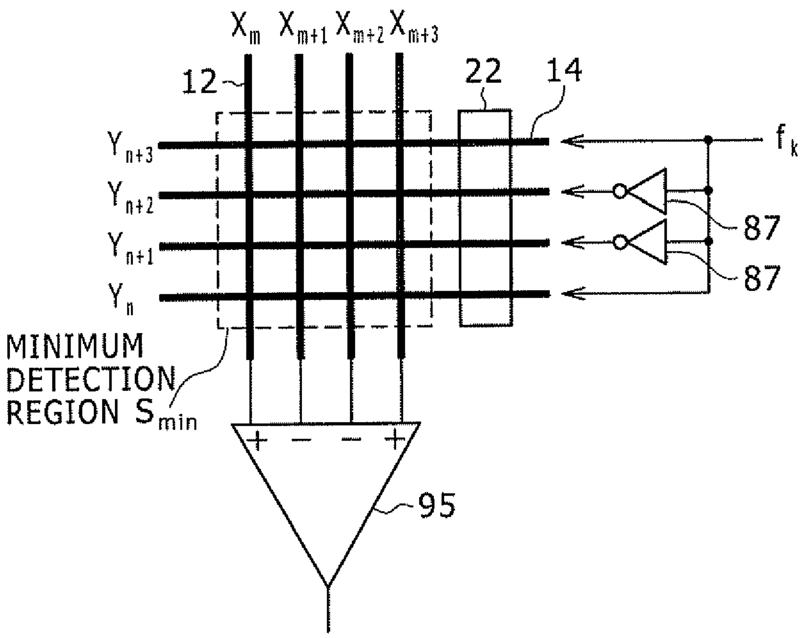

X_m
X_{m+1}
X_{m+2}
X_{m+3}
12
22
14
f_k
Y_{n+3}
Y_{n+2}
Y_{n+1}
Y_n
87
87
MINIMUM DETECTION REGION S_{min}
+ − − +
95

FIG.33A

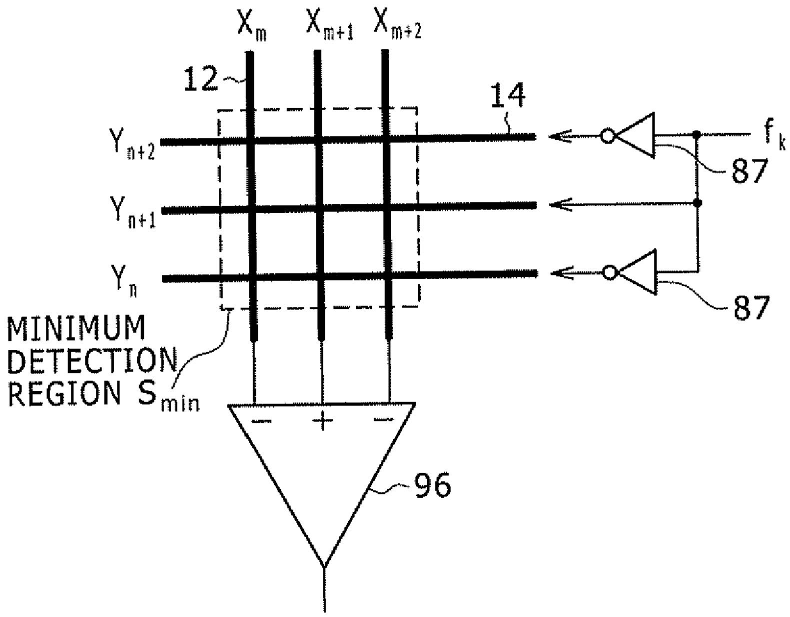


FIG.33B

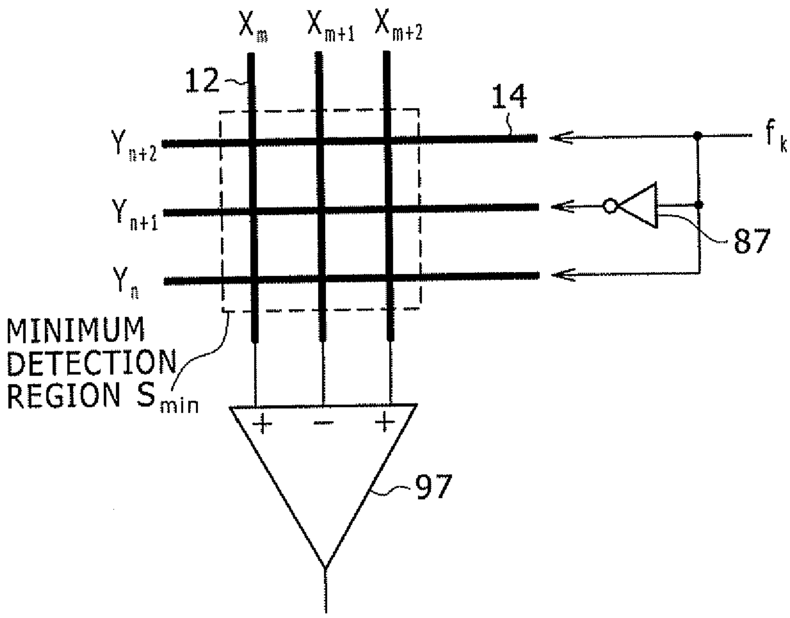


FIG.34

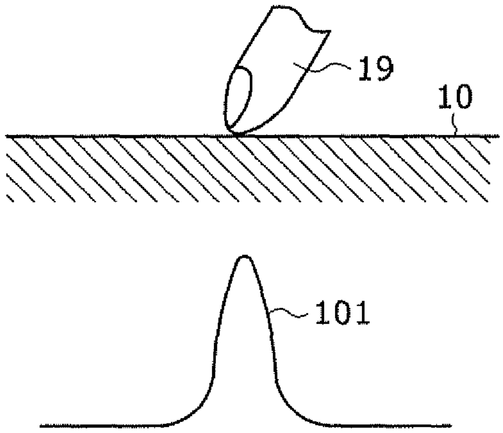


FIG.35

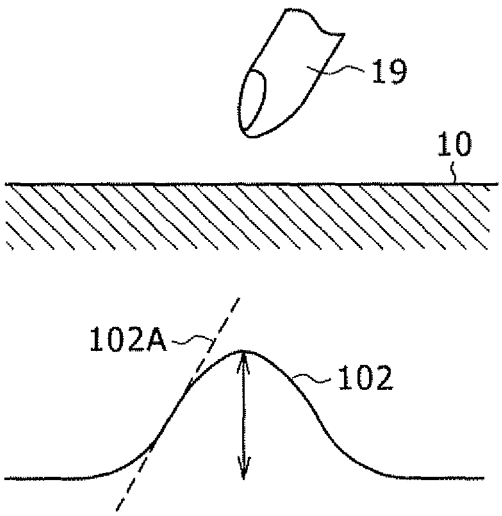


FIG.36

20	50	20
50	100	50
20	50	20

FIG.37

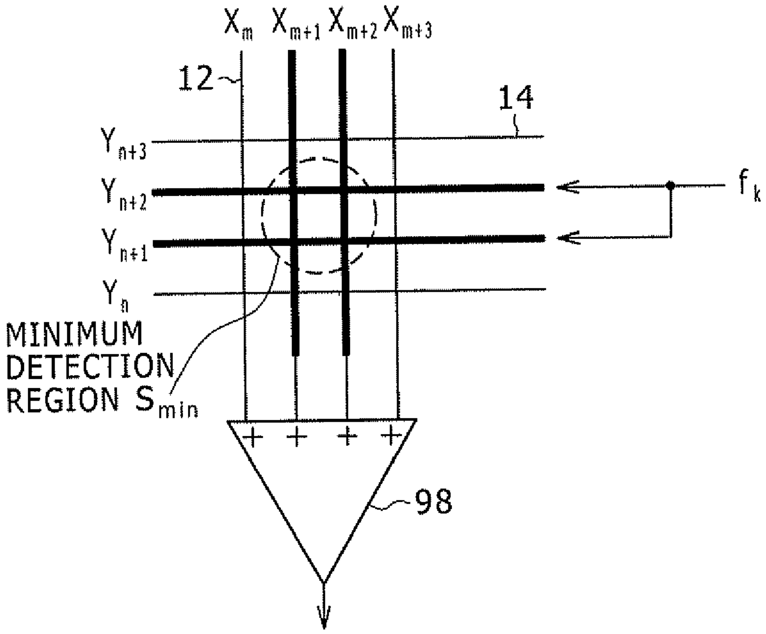

X_m
X_{m+1}
X_{m+2}
X_{m+3}
12
14
Y_{n+3}
Y_{n+2}
Y_{n+1}
Y_n
f_k
MINIMUM DETECTION REGION S_{min}
+ + + +
98

FIG.38

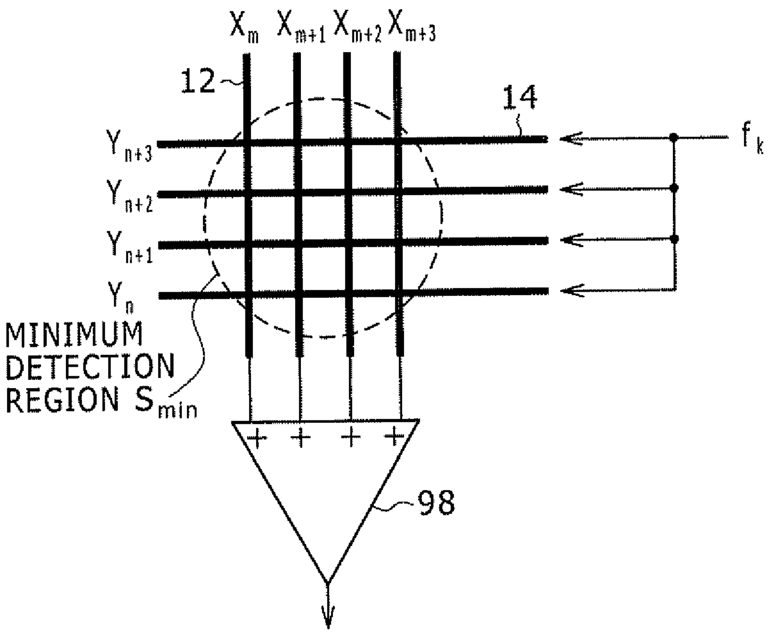

X_m X_{m+1} X_{m+2} X_{m+3}
12
14
f_k
Y_{n+3}
Y_{n+2}
Y_{n+1}
Y_n
MINIMUM DETECTION REGION S_{min}
+ + + +
98

FIG.39

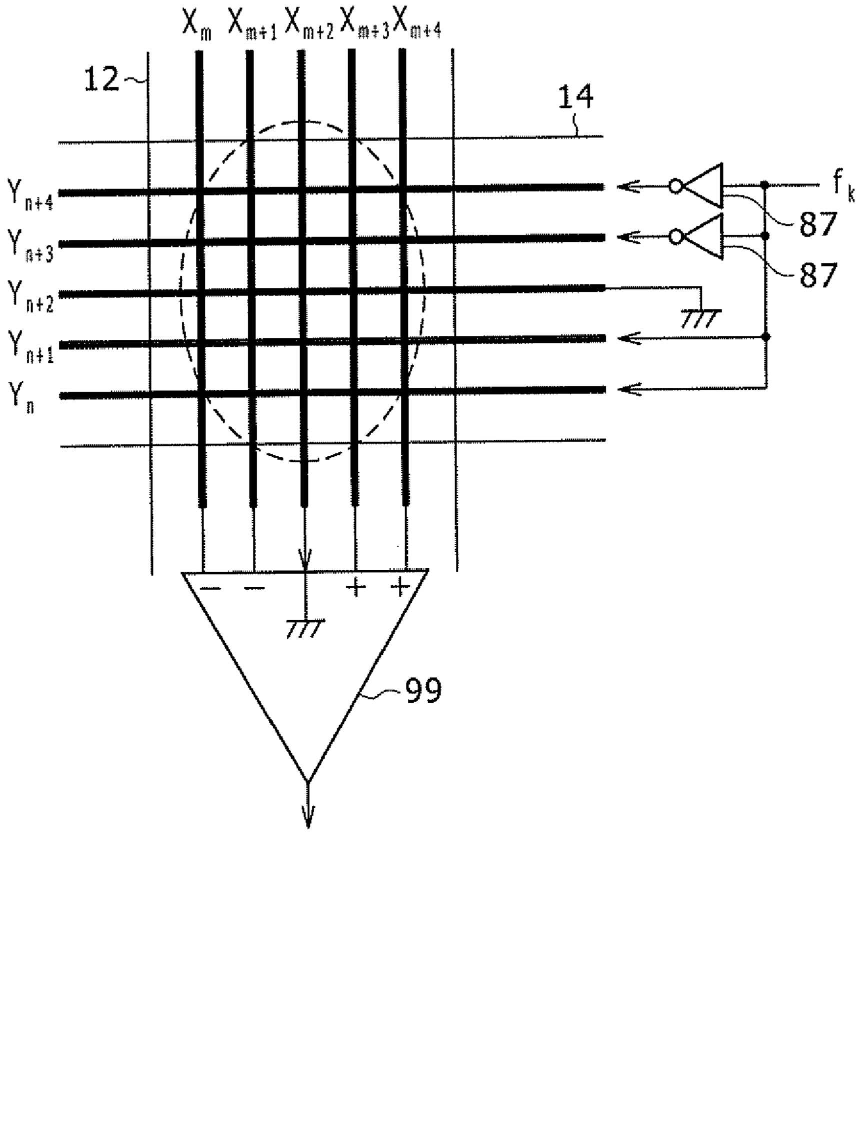


FIG.40

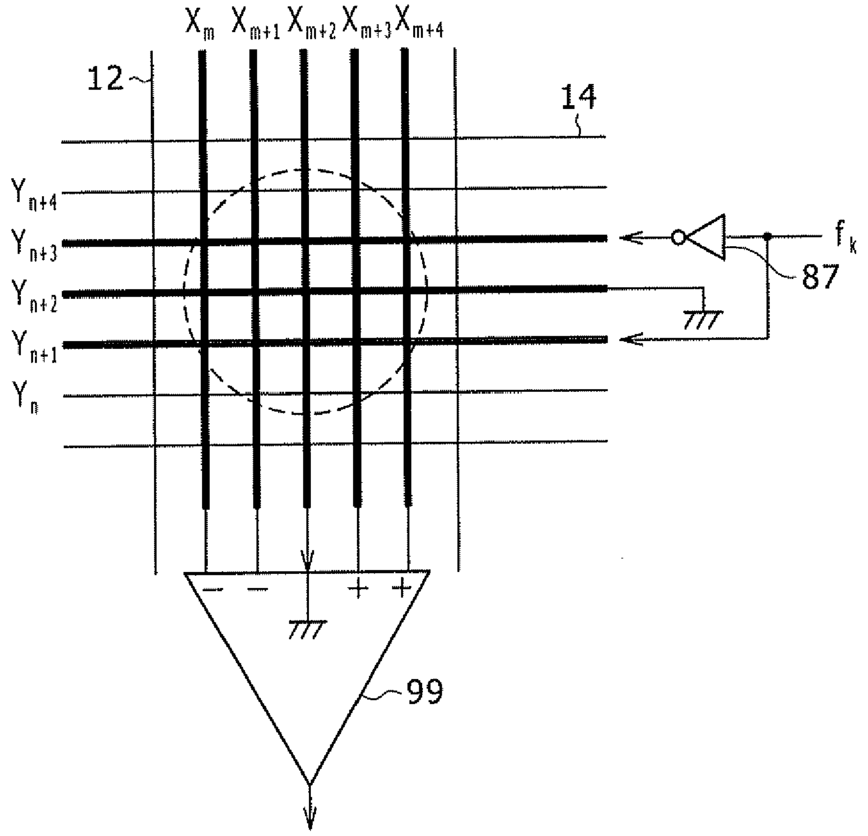


FIG.41

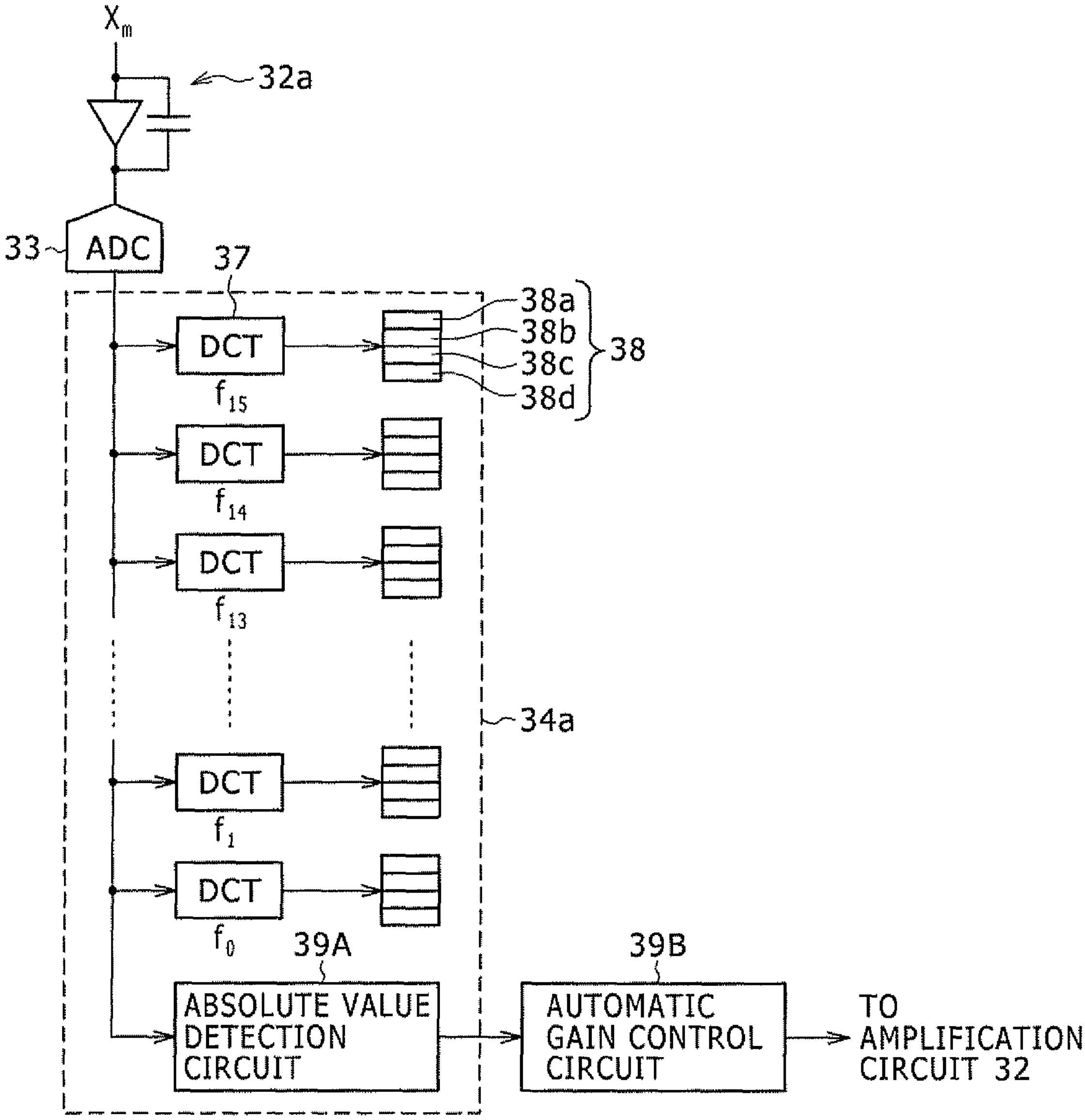

X_m
32a
33
ADC
37
DCT
f_{15}
38a
38b
38c
38d
38
DCT
f_{14}
DCT
f_{13}
34a
DCT
f_1
DCT
f_0
39A
39B
ABSOLUTE VALUE DETECTION CIRCUIT
AUTOMATIC GAIN CONTROL CIRCUIT
TO AMPLIFICATION CIRCUIT 32

FIG.42

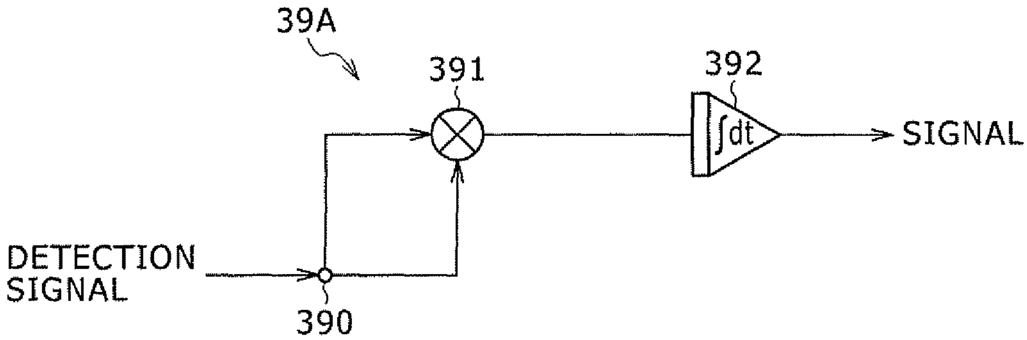

39A
391
392
∫dt
SIGNAL
DETECTION SIGNAL
390

FIG.43A

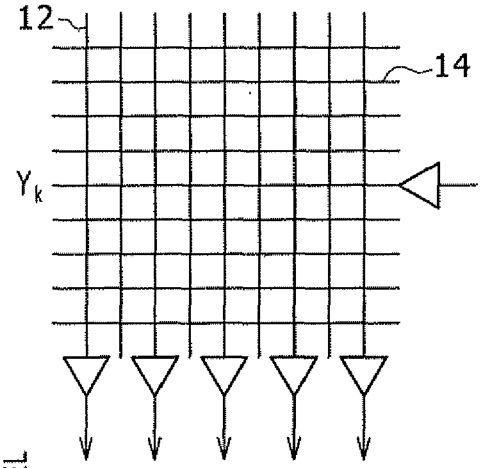


FIG.43B

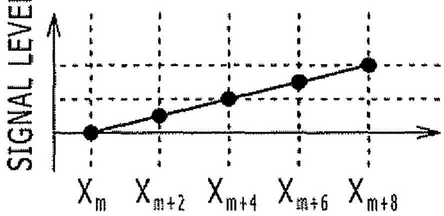


FIG.44A

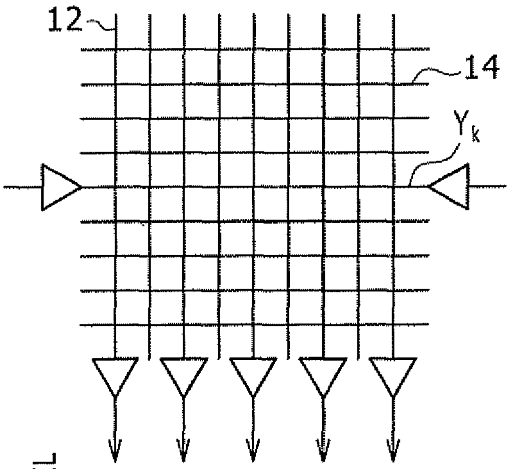


FIG.44B

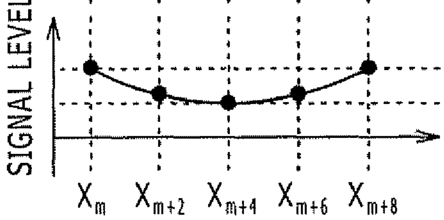


FIG.45A

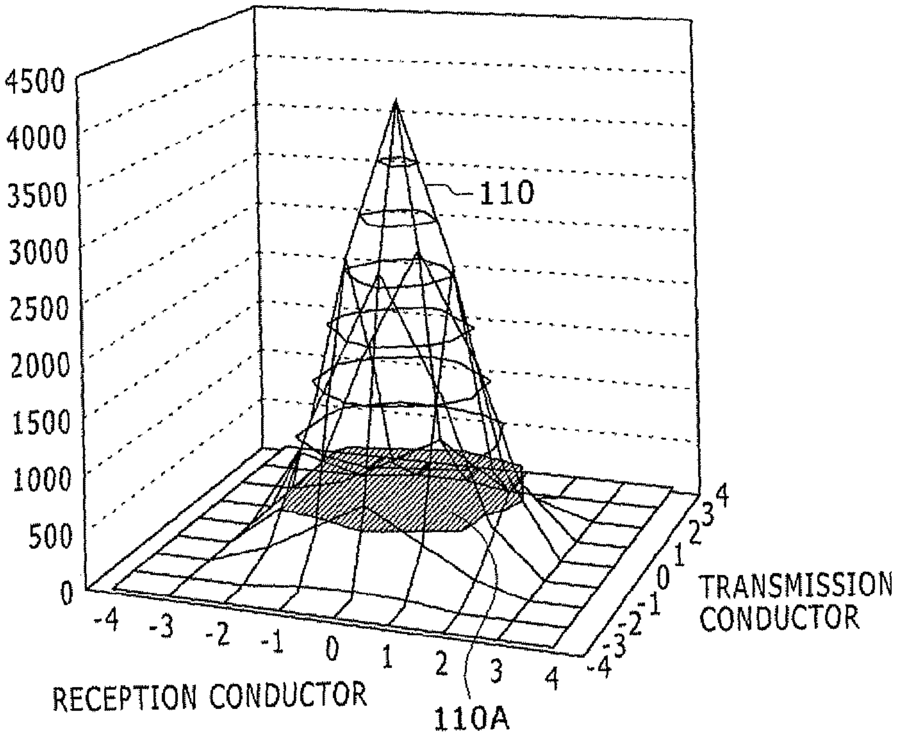


FIG.45B

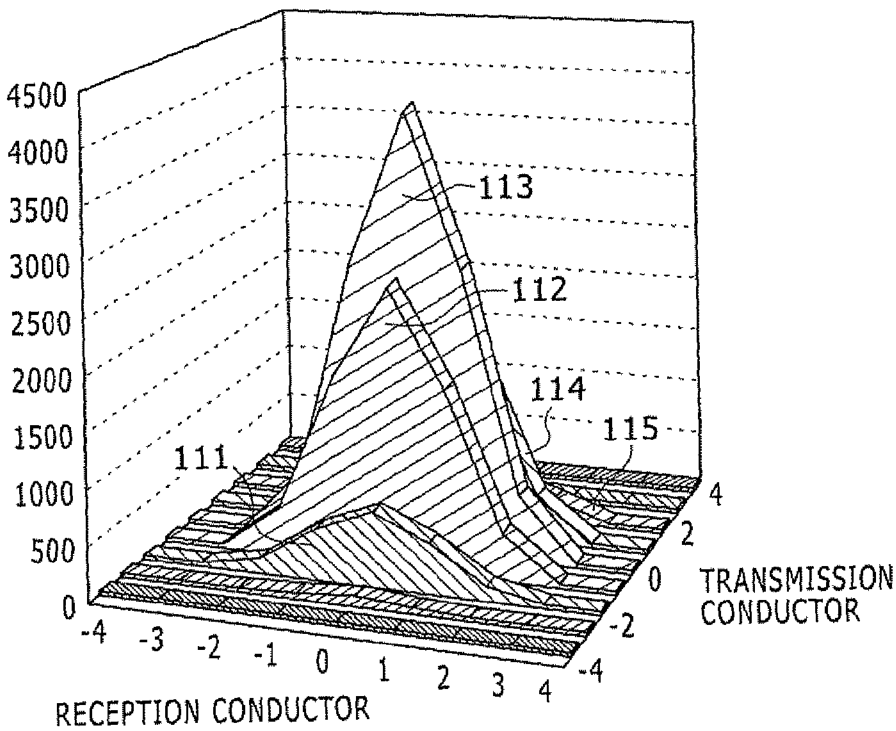


FIG.46

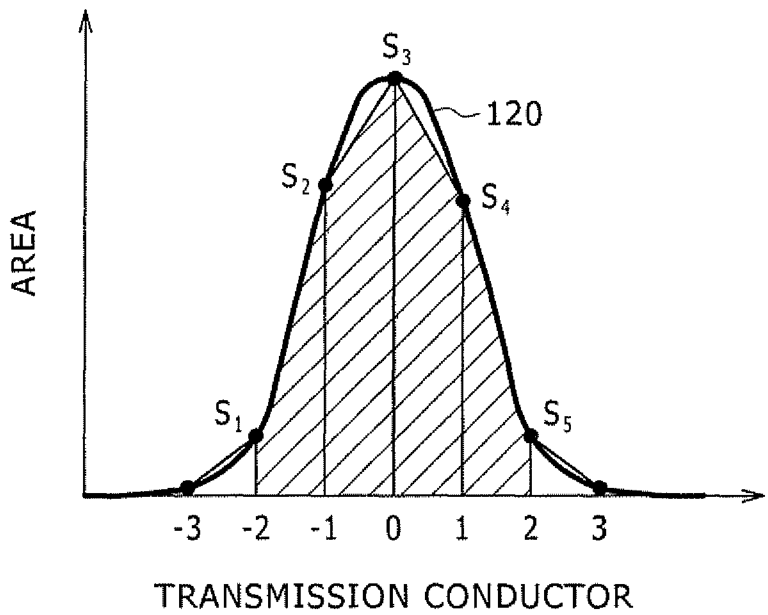


FIG.47

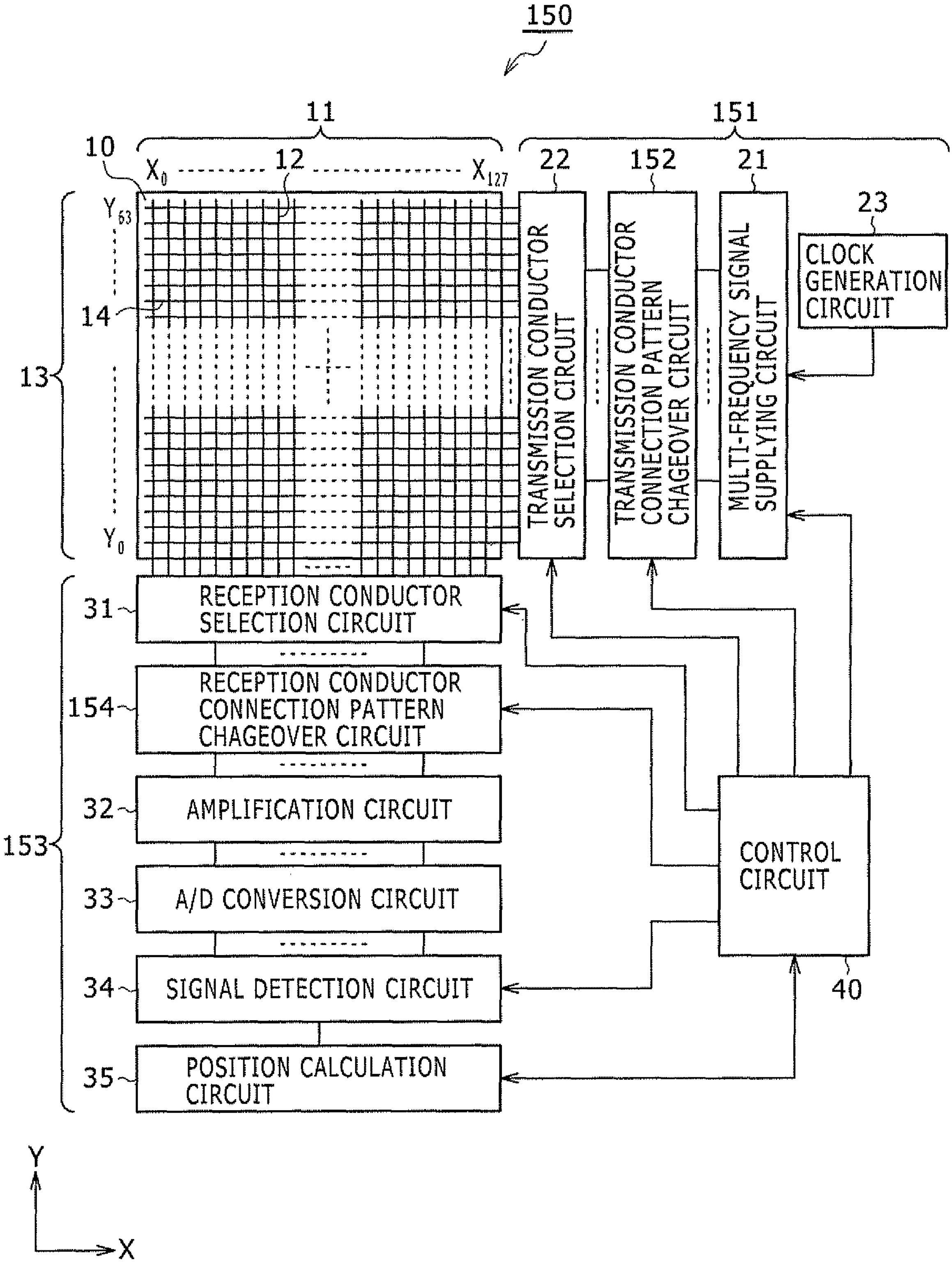

150
11
151
10
X0
12
X127
22
152
21
23
Y63
14
13
Y0
TRANSMISSION CONDUCTOR SELECTION CIRCUIT
TRANSMISSION CONDUCTOR CONNECTION PATTERN CHAGEOVER CIRCUIT
MULTI-FREQUENCY SIGNAL SUPPLYING CIRCUIT
CLOCK GENERATION CIRCUIT
31
RECEPTION CONDUCTOR SELECTION CIRCUIT
154
RECEPTION CONDUCTOR CONNECTION PATTERN CHAGEOVER CIRCUIT
32
AMPLIFICATION CIRCUIT
153
33
A/D CONVERSION CIRCUIT
34
SIGNAL DETECTION CIRCUIT
35
POSITION CALCULATION CIRCUIT
CONTROL CIRCUIT
40
Y
X

FIG.48

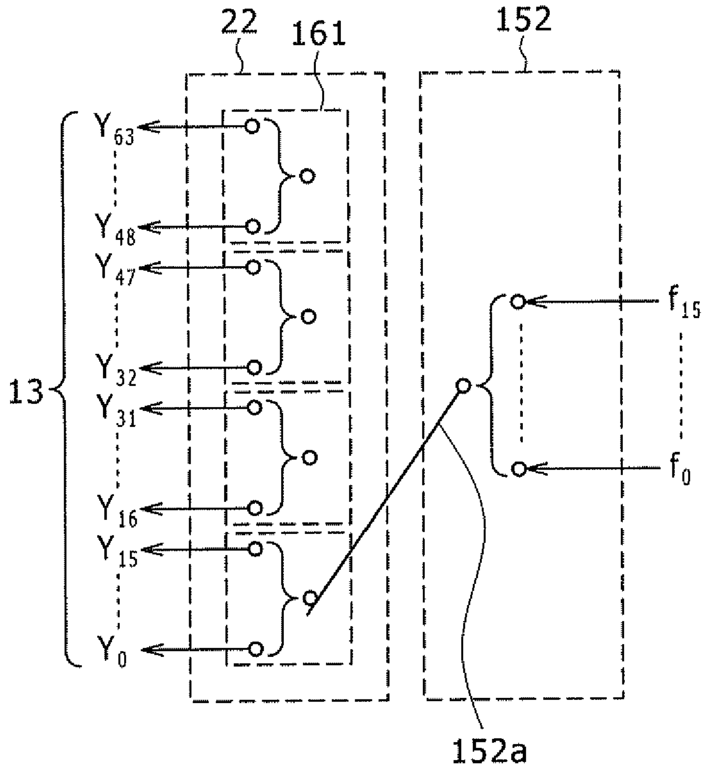


FIG.49A

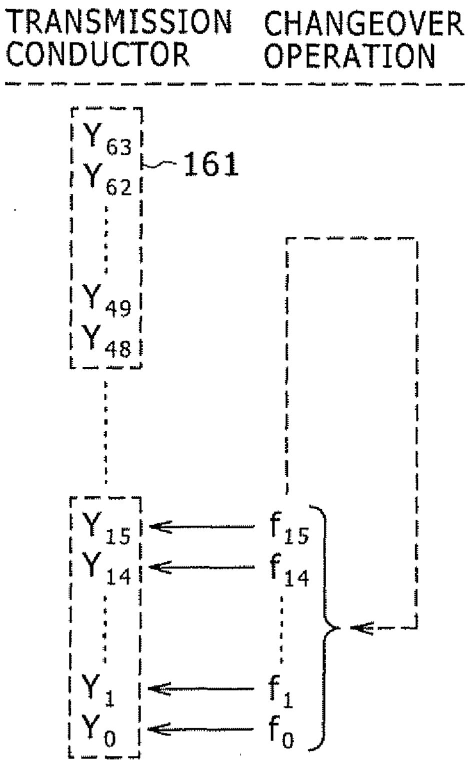


FIG.49B

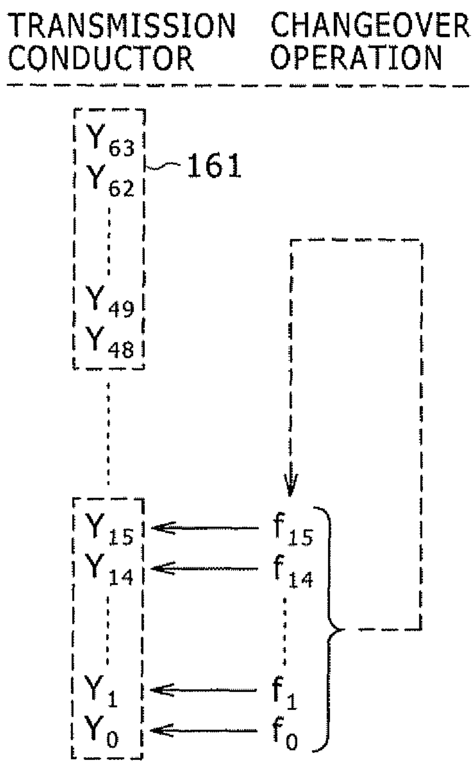


FIG.50

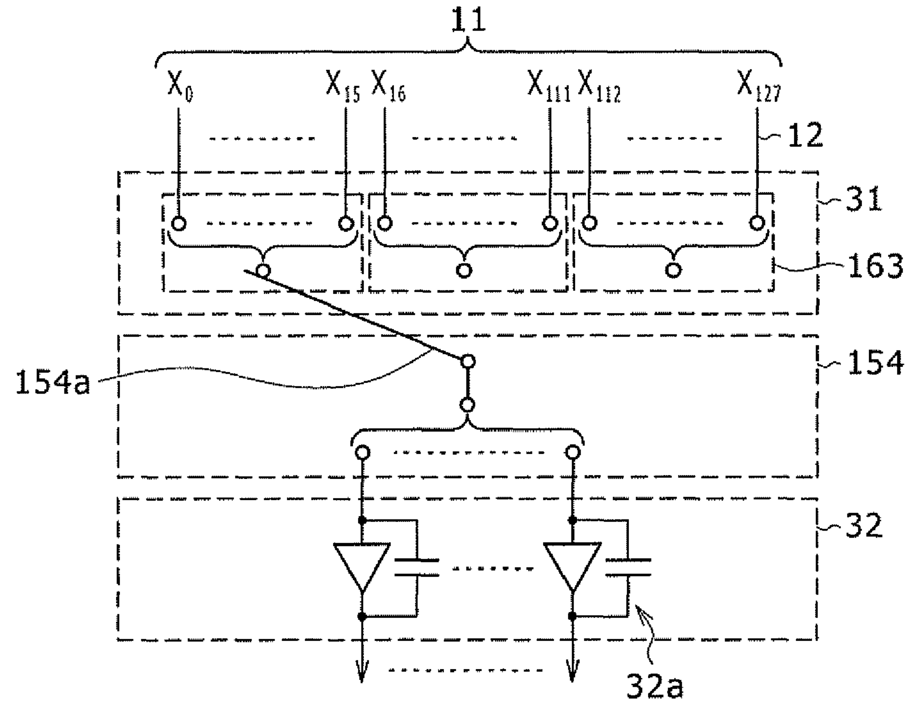

11
X_0
X_{15} X_{16}
X_{111} X_{112}
X_{127}
12
31
163
154a
154
32
32a

FIG.51

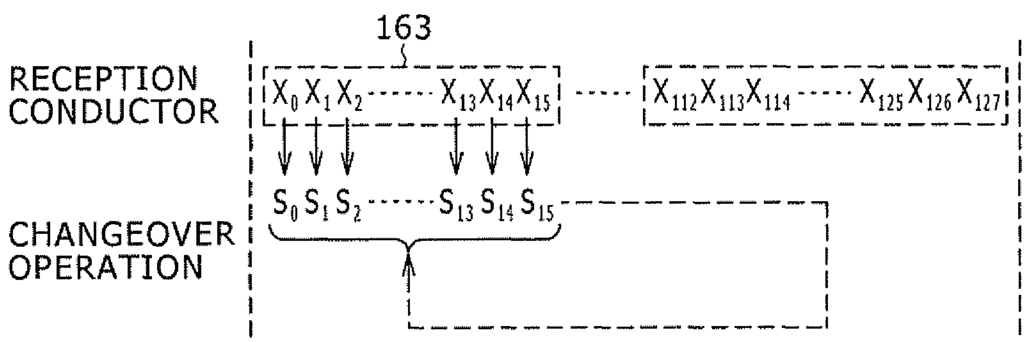

163
RECEPTION CONDUCTOR
X_0 X_1 X_2 X_{13} X_{14} X_{15}
X_{112} X_{113} X_{114} X_{125} X_{126} X_{127}
CHANGEOVER OPERATION
S_0 S_1 S_2 S_{13} S_{14} S_{15}

FIG.52A

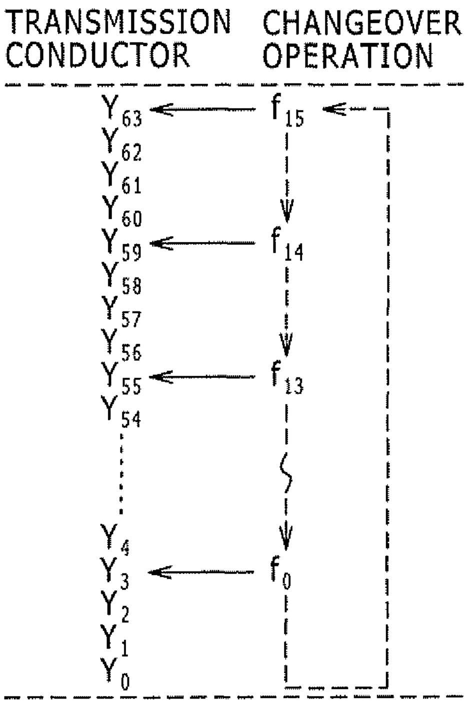


FIG.52B

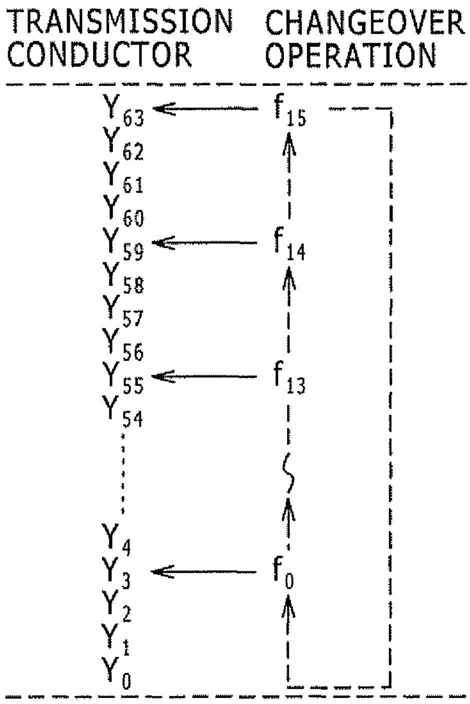


FIG.53A

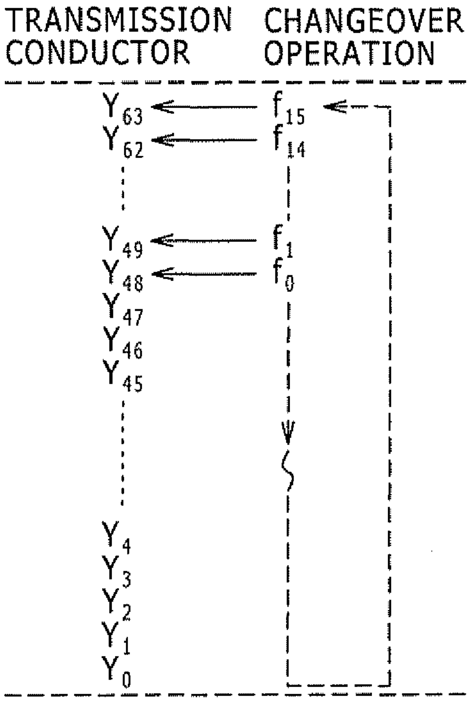


FIG.53B

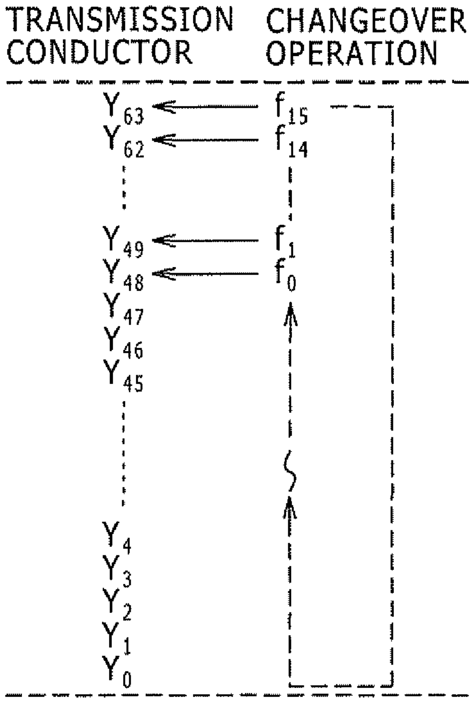


FIG.54

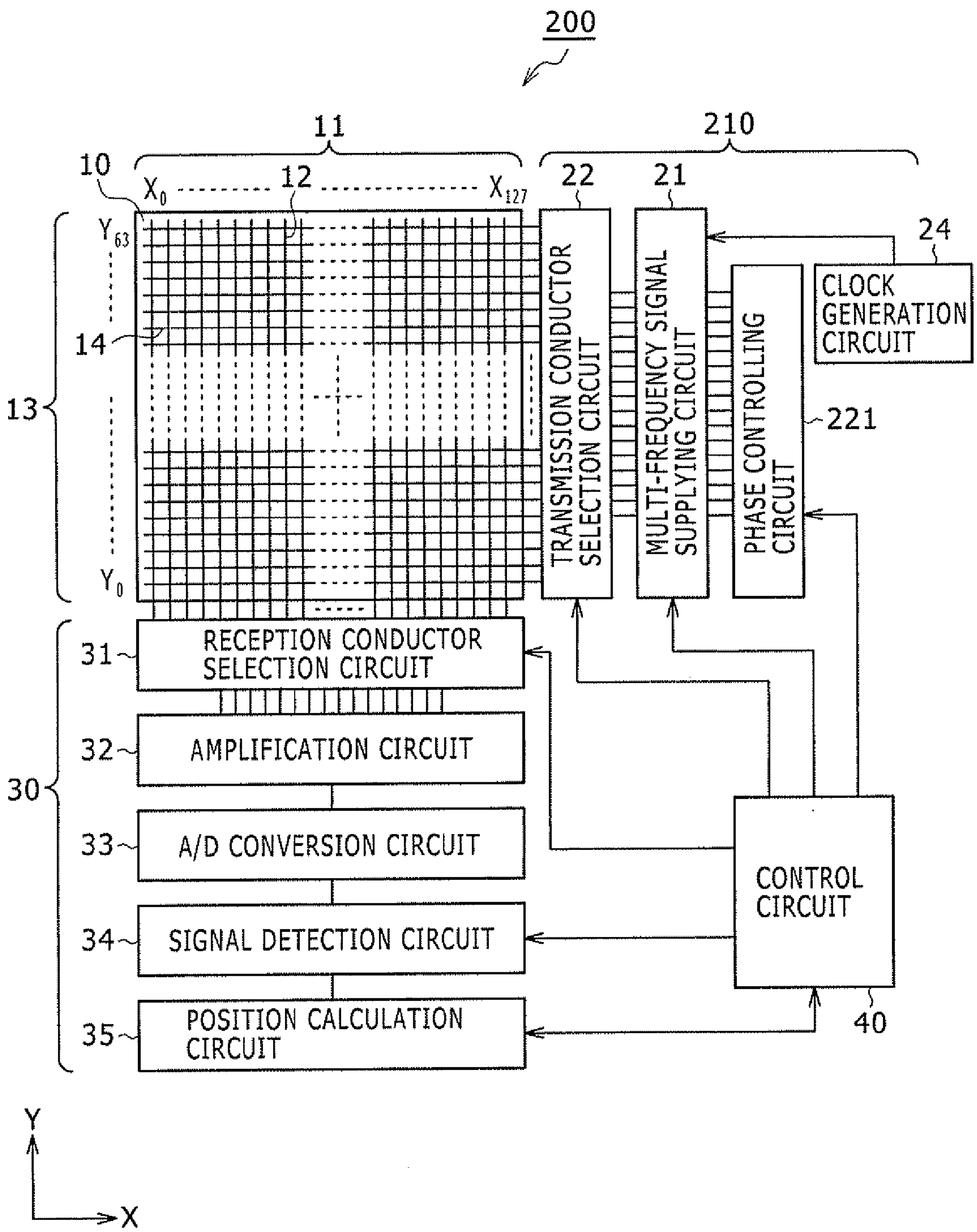
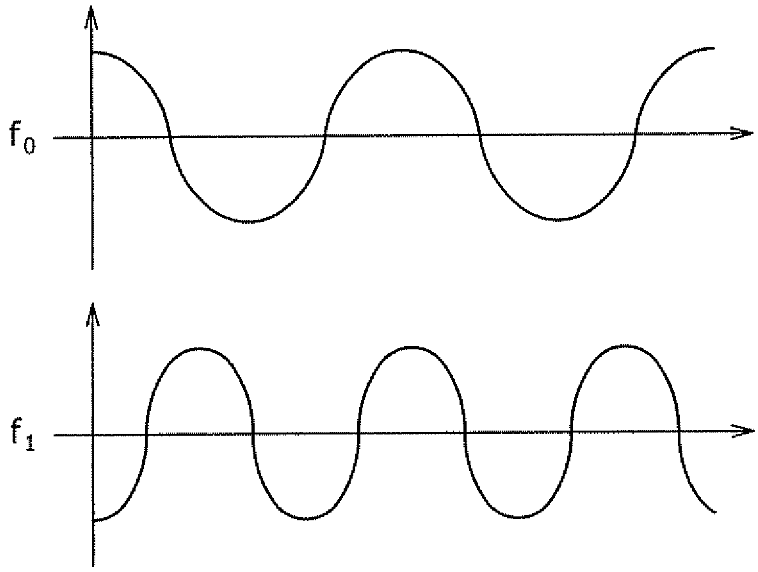
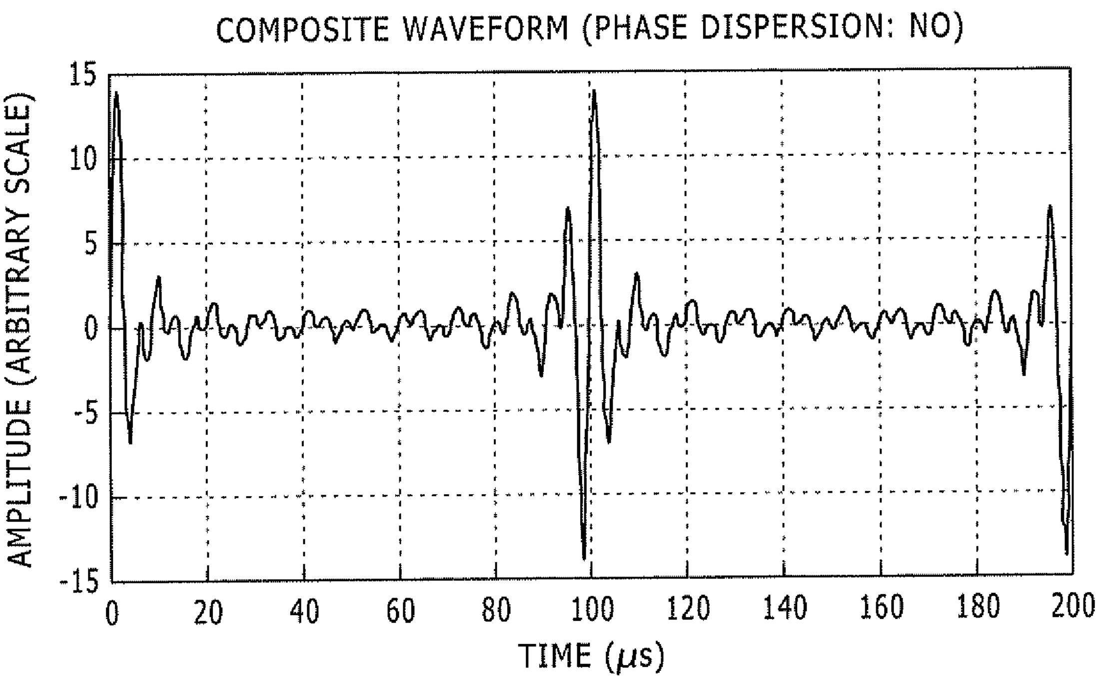

200
11
210
10
X_0
12
X_{127}
22
21
24
Y_{63}
14
13
Y_0
TRANSMISSION CONDUCTOR SELECTION CIRCUIT
MULTI-FREQUENCY SIGNAL SUPPLYING CIRCUIT
PHASE CONTROLLING CIRCUIT
221
CLOCK GENERATION CIRCUIT
31
RECEPTION CONDUCTOR SELECTION CIRCUIT
32
AMPLIFICATION CIRCUIT
30
33
A/D CONVERSION CIRCUIT
34
SIGNAL DETECTION CIRCUIT
35
POSITION CALCULATION CIRCUIT
CONTROL CIRCUIT
40
Y
X

FIG.55



f_0
f_1

FIG.56



COMPOSITE WAVEFORM (PHASE DISPERSION: NO)
AMPLITUDE (ARBITRARY SCALE)
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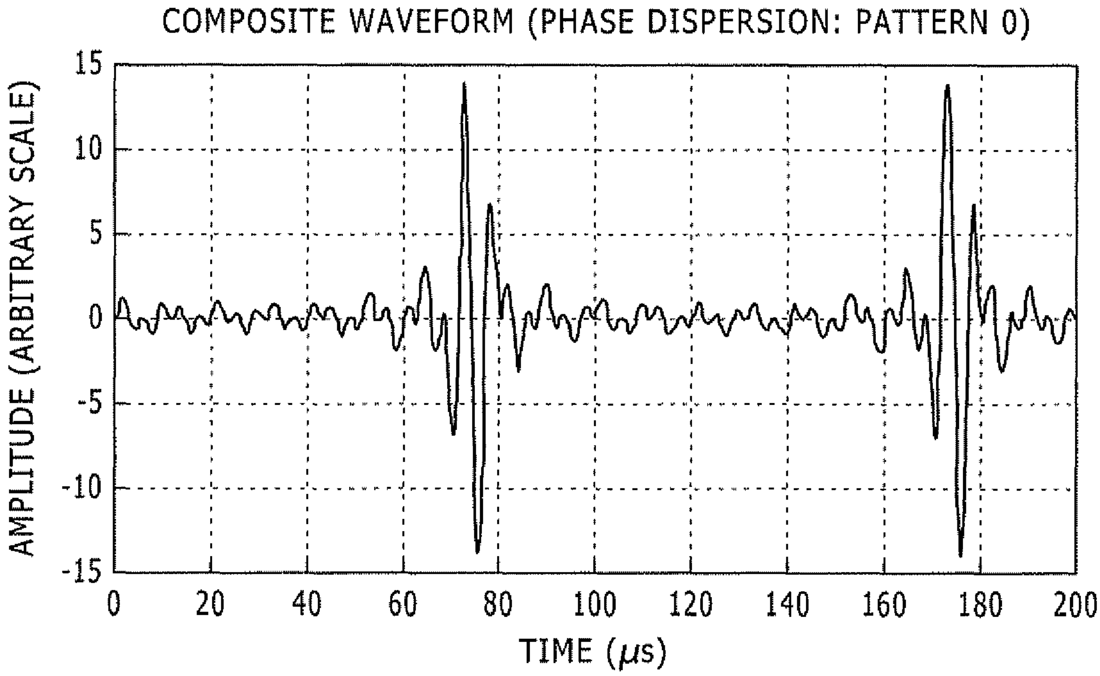
10
5
0
-5
-10
-15
0
20
40
60
80
100
120
140
160
180
200
TIME (μs)

FIG.57


COMPOSITE WAVEFORM (PHASE DISPERSION: PATTERN 0)
AMPLITUDE (ARBITRARY SCALE)
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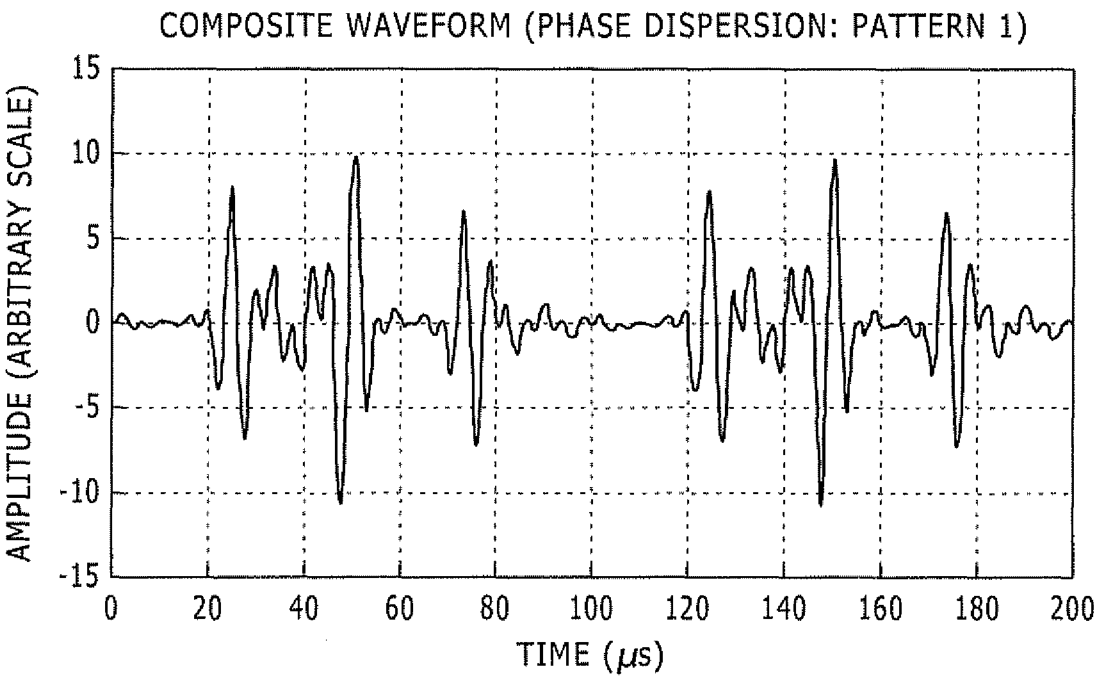
100
120
140
160
180
200
TIME (μs)

FIG.58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AMPLITUDE (ARBITRARY SCALE)
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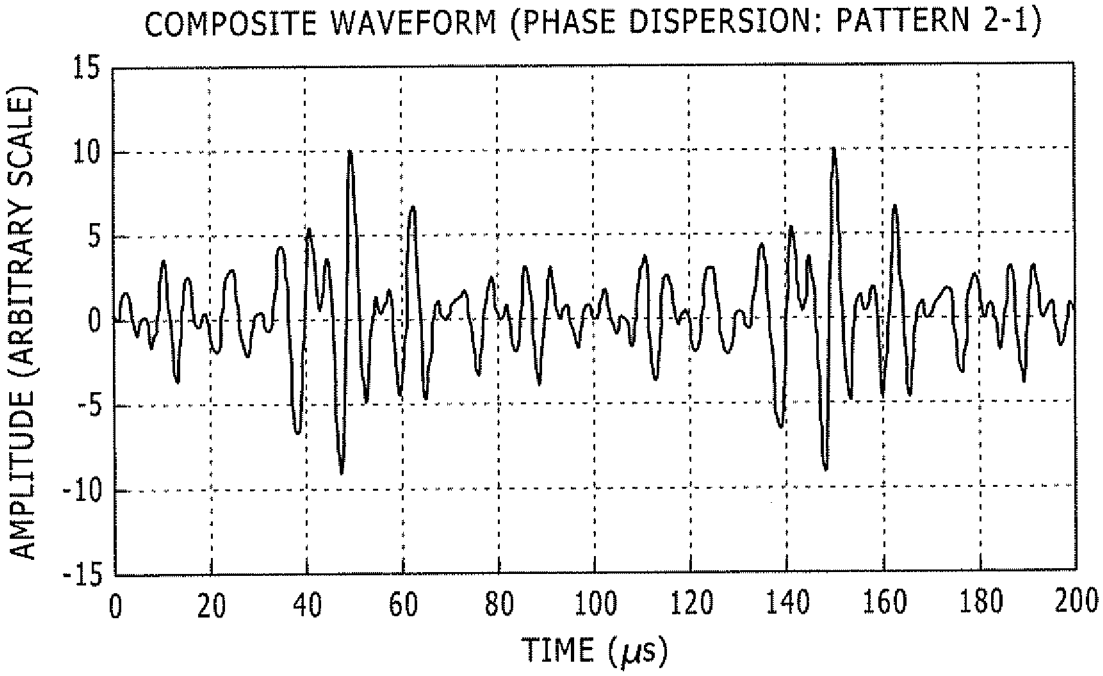
40
60
80
100
120
140
160
180
200
TIME (μs)

FIG.59


COMPOSITE WAVEFORM (PHASE DISPERSION: PATTERN 2-1)
AMPLITUDE (ARBITRARY SCALE)
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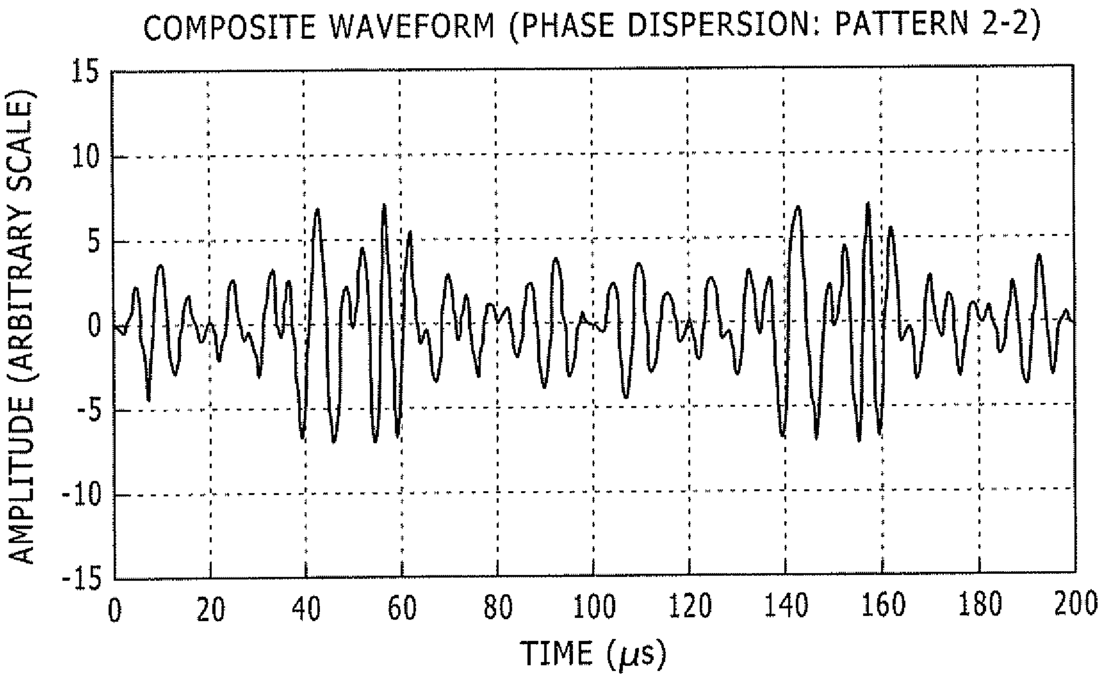
140
160
180
200
TIME (μs)

FIG.60


COMPOSITE WAVEFORM (PHASE DISPERSION: PATTERN 2-2)
AMPLITUDE (ARBITRARY SCALE)
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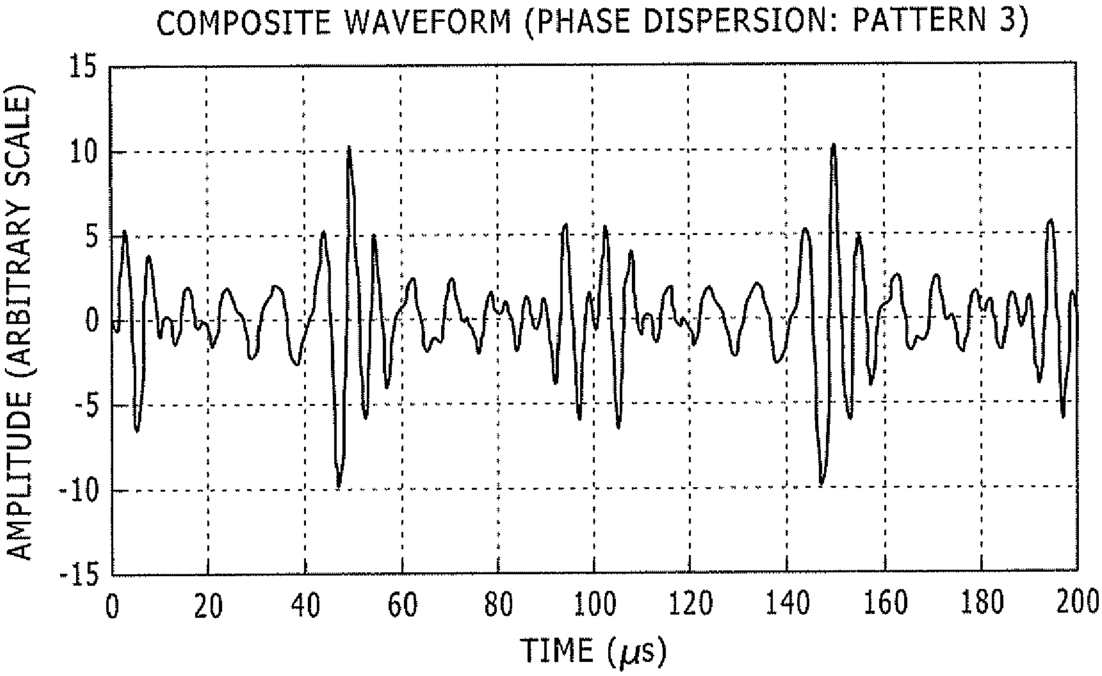
140
160
180
200
TIME (μs)

FIG.61


COMPOSITE WAVEFORM (PHASE DISPERSION: PATTERN 3)
AMPLITUDE (ARBITRARY SCALE)
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80
100
120
140
160
180
200
TIME (μs)

FIG.62A

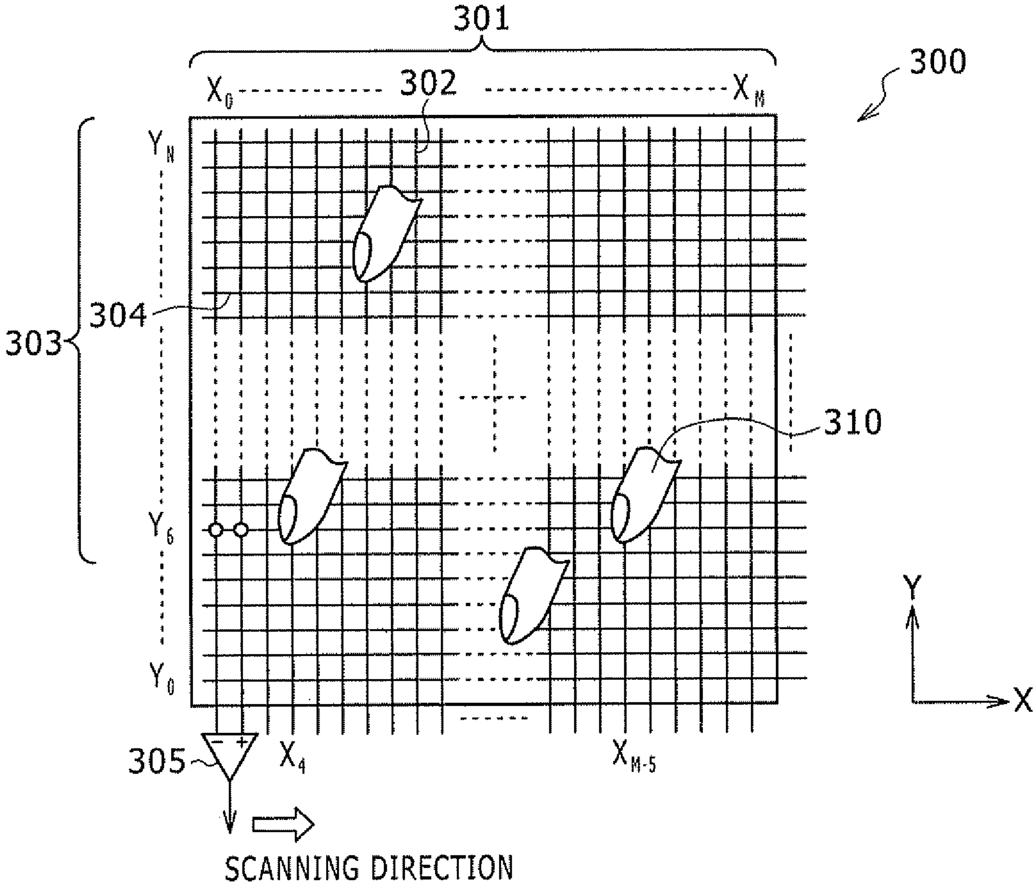
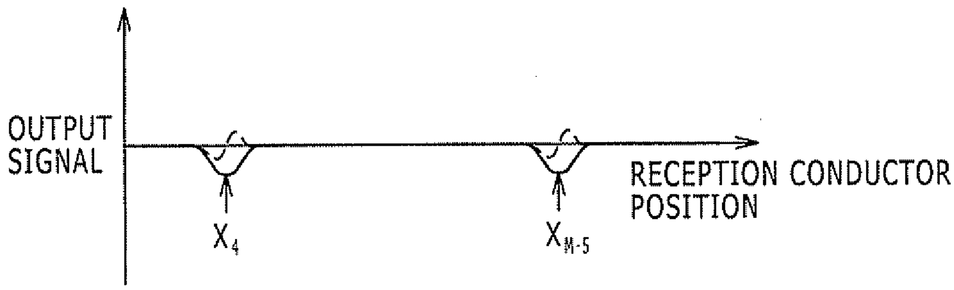


FIG.62B



Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 10 15 8402

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 2008/085719 A2 (APPLE INC [US]; HOTELLING STEVE PORTER [US]; ELIAS JOHN GREER [US]; SA) 17 July 2008 (2008-07-17) * the whole document *	1-9	INV. G06F3/046
X	US 2009/009483 A1 (HOTELLING STEVE PORTER [US] ET AL) 8 January 2009 (2009-01-08) * abstract * * paragraphs [0004], [0006] - [0008], [0 34], [0 37], [0 41], [0 48] *	1-9	
A	US 2008/158180 A1 (KRAH CHRISTOPH HORST [US] ET AL) 3 July 2008 (2008-07-03) * abstract * * paragraphs [0052], [0 54]; claim 1 *	1-9	
A	US 2008/309625 A1 (KRAH CHRISTOPH HORST [US] ET AL) 18 December 2008 (2008-12-18) * abstract * * claim 1 *	1-9	
A	US 2008/158175 A1 (HOTELLING STEVE PORTER [US] ET AL) 3 July 2008 (2008-07-03) * abstract * * paragraphs [0078], [0079]; figures 3B,14 *	1-9	TECHNICAL FIELDS SEARCHED (IPC) G06F
A	US 2008/062139 A1 (HOTELLING STEVE P [US] ET AL) 13 March 2008 (2008-03-13) * abstract * * figures 5-7, 13, 92, 93 *	1-9	

~~The present search report has been drawn up for all claims~~

Place of search	Date of completion of the search	Examiner
Munich	18 June 2010	Schneider, Michael

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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Europäisches Patentamt
European Patent Office
Office européen des brevets

Application Number
EP 10 15 8402

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing claims for which payment was due.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☐ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☒ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

1-9

☐ The present supplementary European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims (Rule 164 (1) EPC).

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LACK OF UNITY OF INVENTION SHEET B

Application Number
EP 10 15 8402

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1-9

   The common features as defined in claim 1, and additional features related to the division of the plurality of first conductors into a plurality of groups and/or features related to the phase controlling circuit.

   ---

2. claims: 10-12

   The common features as defined in claim 1, and additional features related to the arrangement of the conductor pattern.

   ---

3. claims: 13-15

   The common features as defined in claim 1, and additional features related to the calculation of the pointer from the received signals.

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 10 15 8402

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

18-06-2010

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2008085719 A2	17-07-2008	AU 2008100002 A4	07-02-2008
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		CN 201293982 Y	19-08-2009
		DE 202007018134 U1	30-04-2008
		EP 2111572 A2	28-10-2009
		HK 1108273 A2	02-05-2008
		US 2008158167 A1	03-07-2008
US 2009009483 A1	08-01-2009	NONE	
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		US 2008062147 A1	13-03-2008
		US 2008062148 A1	13-03-2008
		US 2008062140 A1	13-03-2008

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP HEI5224818 B **[0004]**
- JP HEI64213 B **[0004]**
- JP HEI7141088 B **[0004]**
- JP HEI887369 B **[0004]**
- JP HEI8179871 B **[0004]**
- JP HEI8190453 B **[0004]**
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- JP HEI10161795 B **[0004]**

BAR CODE LABEL

PCT/US 93/04365
U.S. PATENT APPLICATION

93911170.4

SERIAL NUMBER	FILING DATE	CLASS	GROUP ART UNIT
07/882.171	05/08/92	424	1811

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CONTINUING DATA********************

VERIFIED THIS APPLN IS A CIP OF 07/698,927 05/13/91
WHICH IS A CIP OF 07/613,066 11/14/90

REC'D 19 JUL 1993
WIPO PCT

FOREIGN/PCT APPLICATIONS**********

VERIFIED

PRIORITY DOCUMENT

STATE OR COUNTRY	SHEETS DRAWING	TOTAL CLAIMS	INDEPENDENT CLAIMS	FILING FEE RECEIVED	ATTORNEY DOCKET NO.
PA	43	25	11	$1,496.00	H85009

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TITLE

COMPOSITIONS AND METHODS FOR VACCINATION AGAINST CORONAVIRUSES

This is to certify that annexed hereto is a true copy from the records of the United States Patent and Trademark Office of the application as filed which is identified above.

By authority of the
COMMISSIONER OF PATENTS AND TRADEMARKS

Date MAY 26 1993 Certifying Officer P. Sullivan

SBC H85009

COMPOSITIONS AND METHODS FOR VACCINATION AGAINST CORONAVIRUSES

Cross-Reference to Related Applications

This is a continuation-in-part of pending U.S. patent application Serial No. 07/698,927, filed May 13, 1991, which is a continuation-in-part of U.S. patent application Serial No. 07/613,066, filed November 14, 1990.

Field of the Invention

This invention relates generally to compositions useful for vaccination against, and treatment of, coronavirus infections, as well as methods for using these compositions.

Background of the Invention

Feline Infectious Peritonitis Virus (FIPV) is a coronavirus which causes a highly lethal immune complexing disease in cats. The exact mechanism(s) of FIP disease pathogenesis is not understood, but lesions are found in all major internal organs due to the deposition of immune complexes. Several strains of FIPV have been isolated from diseased cats. Some are highly virulent and cause disease after a primary infection (Type II). Other virulent strains (Type I) cannot initiate disease unless the cat has been previously exposed to FIPV.

Other corovaviruses have also been isolated from other animal species. However, these coronaviruses do not share the same pathogenesis as FIPV. Rather, they cause either respiratory or gastroenteritis illnesses. The sequences of some of these coronaviruses have been identified. For example, P. Britton et al, have published the porcine respiratory coronavirus (PRCV) in Genbank. The sequence of bovine coronavirus (BCV) strain Mebus is provided in Abraham et al, Virol., 176:296-301 (1990) and strain F15 is provided in Boireau et al, J. Gen. Virol., 71:487-492 (1990). The sequence of avian coronavirus (ACV) is provided in M. Binnes et al, J. Gen. Virol., 66:719-726 (1985). The sequence of murine coronavirus (MCV) is provided in I. Schmidt et al, J. Gen. Virol., 68:47-56 (1987). A human coronavirus (HCV) sequence is provided in T. Raabe et al, J. Gen. Virol., 71:1065-1073 (1990).

Coronaviruses encode three structural proteins: S - surface glycoprotein or spike; M - the envelope matrix protein; and N - the nucleoprotein which interacts with the RNA genome to make the viral capsid. The S protein induces an immune response including the production of neutralizing antibodies following infection. It is also responsible for attachment to infected cells and mediates cell fusion, aiding spread of the virus.

The sequence of the S gene of the wild-type WSU 1146 strain of FIPV has been published [DeGroot et al, J. Gen. Virol., 68:2639-2646 (1987)]. Wild-type FIPV strains are highly virulent in cats; the S gene alone of a virulent FIPV can sensitize cats to disease. A strong humoral response to the S gene, then, appears responsible for the immune complexes found in diseased cats. However, little is known about the location of antigenic/neutralizing epitopes on the FIPV S gene.

In contrast, substantial progress has been made in mapping antigenic and neutralizing sites on the porcine coronavirus, transmissible gastroenteritis virus (TGEV). Two groups, Enjuanes [Correa et al, J. Gen. Virol., 71:271-279 (1990)] and Delmas [Delmas et al, J. Gen. Virol., 71:1313-1323 (1990)], have defined four major antigenic sites on the TGEV spike protein, called A, B, C and D.

Attempts to product a safe, effective vaccine against FIPV have been largely unsuccessful. Administration of sublethal doses of virulent FIPV, avirulent FIPV strains or other antigenically related coronaviruses has not been effective. Previous exposure to the virus typically exacerbates the disease due to the strong humoral response to FIPV infection. More recently, a vaccine has been produced which consists of a live virus temperature-sensitive strain of DF2 FIPV [Primucell; SmithKline Beecham]. When this vaccine is administered oro-nasally, it protects, but does not sensitize, cats to wild-type DF2 FIPV. However, this vaccine does not elicit a strong cross-strain reaction and does sensitize if administered parenterally.

Recombinant vaccines have been engineered which consist of FIPV gene products produced in a heterologous expression system. Vennema et al, J. Virol., 64:1407-1409 (1990) constructed vaccinia virus recombinants expressing the S, M, and N genes of FIPV (Type II, WSU 1146 strain). Cats immunized with the recombinant vaccinia virus expressing the S gene developed FIP and died sooner than non-vaccinated animals following FIPV challenge. The vaccinia recombinants expressing the FIPV M or N proteins neither conclusively protected nor sensitized cats to FIPV. While no protection from challenge was observed, these results clearly illustrate that the S gene is implicated in FIP disease development.

There remains a need for effective compositions for use in treating and vaccinating animals against FIPV and serologically related infections.

Summary of the Invention

In one aspect, the present invention provides chimeric coronavirus S gene proteins which are useful in treating and preventing coronavirus infections. These chimeric proteins may contain at least two heterologous S gene fragments selected from the S gene proteins of a number of coronaviruses. The fragments are fused in such a way that a full length S gene protein or an immunogenic fragment thereof is formed. These chimeric proteins are capable of eliciting an immune response to more than one coronavirus strain and/or species and may induce an enhanced response to a single coronavirus strain.

In another aspect, the chimeric S proteins of the invention may contain a deletion of one or more selected coronavirus, preferably, FIPV or FECV, B cell and/or T cell sites resulting in a truncated chimeric S gene. Alternatively, a truncated chimeric S gene may be constructed which comprises one or more T cell sites of a coronavirus fused to at least one B cell site of a coronavirus.

In another aspect, the present invention provides a chimeric polynucleotide sequence which encodes a chimeric S protein described above.

In another aspect, the present invention provides a recombinant polynucleotide molecule comprising a chimeric S gene polynucleotide sequence in operative association with regulatory sequences capable of directing the replication and expression thereof in a selected host cell. In another aspect, a recombinant protein comprising about amino acids 1115 to about amino acids 1238 of a coronavirus.

In still a further aspect the present invention provides a host cell transformed with a recombinant polynucleotide molecule as described above, as well as a method of producing the recombinant proteins by culturing these cells and isolating the proteins from cell culture by conventional means.

In still another aspect, the invention provides a pharmaceutical composition comprising an immunogenic amount of one or more of the chimeric coronavirus S proteins of the invention or fragments thereof in a suitable carrier. These chimeric coronavirus S proteins are useful in the treatment or prophylaxis of a disease caused by the coronavirus from which its fragments are derived and may induce cross-strain and cross-species responses.

Thus, in another aspect, the invention provides a method for vaccinating a naive animal against a coronavirus, or treating an infected animal for coronavirus infection, both by administering an effective dosage of a pharmaceutical composition of the invention to the animal.

In another aspect the present invention provides a method of distinguishing between animals vaccinated with a chimeric S protein of the invention and an animal which has been naturally exposed to the coronavirus or coronaviruses which comprise the chimeric S protein. Thus, another aspect of this invention provides a diagnostic kit for use in clinical laboratories which is capable of making such a distinction. It is anticipated that the truncated chimeric S proteins containing a deletion of one or more epitopes may be particularly useful in such a method and a kit.

Other aspects and advantages of the present invention are described further in the following detailed description of the preferred embodiments thereof.

Brief Description of the Drawings

Figure 1 illustrates the complete S gene nucleotide [SEQ ID NO: 1] and amino acid [SEQ ID NO: 2] sequence of DF2 FIPV. Also illustrated is a fragment of the sequences of DF2-HP [SEQ ID NO: 3 and 4] which are identical to the sequences of DF2-FIPV (to the extent DF2-HP FIPV has been sequenced) with the exception of the nucleotide changes above and amino acid difference below the DF2-HP sequences.

Figure 2 illustrates a fragment of the S gene TS-BP nucleotide [SEQ ID NO: 5] and amino acid [SEQ ID NO: 6] sequences by indicating the positions where the sequences differ from the sequences of TS FIPV [SEQ ID NO: 7 and 8]. The entire TS FIPV S gene sequence is provided.

Figure 3 illustrates a fragment of the S gene nucleotide and amino acid sequences [SEQ ID NO: 9 and 10] of TN406.

Figure 4 illustrates the complete nucleotide and amino acid [SEQ ID NO: 11 and 12] sequences of an FECV S gene.

Figure 5 illustrates fragments of the nucleotide and amino acid sequences [SEQ ID NO: 13 and 14] of the UCD-2 S gene.

Figure 6 illustrates the nucleotide and amino acid sequences [SEQ ID NO: 15 and 16] of a consensus partial S gene obtained from comparison of the available feline coronavirus strains including the published WT WSU 1146 and those sequences provided herein.

Figure 7 illustrates partial nucleotide and potative amino acid sequences [SEQ ID NO: 17 and 18] of a canine coronavirus (CCV) S gene. Approximately 128-130 amino terminal amino acids and the coding sequences therefor are missing from the protein.

Detailed Description of the Invention

The present invention provides novel chimeric coronavirus S proteins useful for vaccination against, and treatment of coronavirus infection, as well as methods for producing these proteins and pharmaceutical compositions containing them. Methods for using these novel chimeric proteins in the identification of the immune sensitizing and protective "epitopes" of the coronavirus spike protein are also disclosed.

The chimeric proteins of this invention comprise at least two heterologous S gene fragments selected from the S gene proteins of the related coronaviruses FIPV, FECV, TGEV, PRCV, CCV, BCV, ACV, MCV, or human coronavirus strains. In the chimeric proteins, the fragments are fused in such a way that a full length S protein is formed. Alternatively, a less than full length S protein is formed by association of heterologous S protein fragments. These full-length and truncated chimeric proteins are capable of eliciting an enhanced immune response one coronavirus strain and/or an immune response to more than one coronavirus strain or species.

In one embodiment, a chimeric full length coronavirus S protein comprises a selected fragment of an FIPV S protein fused in frame to a selected fragment of an FECV S protein, or vice versa. In yet another embodiment, the present invention provides a chimeric coronavirus S protein comprising a selected N terminal fragment of FECV S protein fused in frame to a selected fragment of an FIPV S protein, which is fused in frame to a carboxy terminal fragment of FECV S protein. Alternatively, a selected N terminal fragment of FIPV S protein can be fused in frame to a selected FECV S protein fragment, which is in turn, fused in frame to a carboxy terminal fragment of FIPV S protein. Other embodiments include the same arrangements, but utilizing different species coronaviruses, such as those described above.

In still another embodiment, a chimeric S protein of this invention may contain a number of FIPV S protein T cell sites replaced by the corresponding fragments of FECV (or another coronavirus). Alternatively, these FIPV S T cell sites may be fused to FECV S protein neutralizing sites to form yet another chimeric protein according to the invention.

The S protein is the primary focus for effective FIPV vaccine development because it is the target of virus neutralizing antibodies and it contains sensitizing epitopes which genetically could be modified or eliminated to prevent exacerbation of disease. To date, no other FIPV gene products (M or N) have been found to stimulate effective immunity to the virus.

Depending upon the disease type and species against which protection (or treatment) is desired, one may select the appropriate S protein fragments of any of the above identified coronaviruses. Particularly desired coronaviruses for use in supplying S protein fragments for the chimeric proteins of this invention include FECV (Figure 4) and FIPV strains DF2, DF2-HP, TS-BP, TS, TN406, UCD-2, and a consensus partial S protein (Figures 1-3, 5-6). Other FIPV strains may also be useful. Also provided is a partial CCV S protein (Figure 7). In addition, other coronavirus species, including TGEV, PRCV, BCV, AVC, MVC, or human coronavirus may be used to construct the chimeric S proteins of this invention.

Currently, for compositions to be administered to felines, FIPV (Type I, Type II or both) and FECV are the preferred coronaviruses for constructing the chimeric S proteins described in this invention. Another composition which is anticipated to be useful is a chimeric feline/canine coronavirus S protein. Such a chimeric may comprise FIPV and/or FECV proteins fused in frame to CCV protein(s). Other chimerics which may be useful in cross-species coronavirus chimerics include FIPV/TGEV, FIPV/FECV/TGEV, FIPV/TGEV/PRCV, ACV/TGEV, PRCV/ACV/TGEV, or BCV/ACV/TGEV. However, in view of the teachings of the present invention, one of skill in the art could construct other suitable chimeric coronavirus S proteins.

Suitable immunogenic regions of each coronavirus for use in the chimerics of the invention are provided herein. Selecting suitable fragments for fusion into chimeric proteins according to this invention involved analysis of related coronaviruses. TGEV shares a high degree of serological cross-reactivity with FIPV. When comparing the S genes of TGEV and FIPV, the similarity was quite striking, i.e., an 82.2% amino acid identity overall. In particular, these two coronaviruses, despite their species specificity, tissue tropism and different disease etiologies, are remarkably homologous in the carboxy terminal region of the protein (94.4% homology). The sequence of four epitopes on the spike protein of TGEV, as well as the secondary structure, were predicted by computer analysis using programs such as GCG PlotStructure, and these areas are highly conserved between FIPV and TGEV.

By analogy with TGEV spike protein, and from sequences of other feline coronaviruses (see co-pending application SN 07/698,927 incorporated by reference herein), several predicted antigenic sites on the DF2 FIPV S proteins are provided. The amino acid and nucleotide sequences of the virulent wild-type DF2 strain of FIPV are reported in Figure 1. The spike gene sequence of the Type II FIPV strains WSU 1146 and WT DF2 are almost identical (99.6% homology). The spike gene sequences of wild-type DF2 FIPV and another closely related and serologically cross-reactive feline coronavirus, feline enteric coronavirus (FECV), were compared. FECV, in contrast to FIPV, specifically infects intestinal epithelial cells and causes only a mild enteritis in cats. In addition, FECV has not been reported to sensitize cats to disease following challenge with FIPV. Similarity to TGEV, the sequence of the four antigenic epitopes on the spike proteins as well as the secondary structure in these areas were found to be highly conserved. The spike genes from these two viruses share ~95% amino acid homology overall.

The majority of conserved residues are located in the carboxy terminal two-thirds of the S protein of these coronaviruses, e.g. from about amino acids 350 to about 450, and from about 650 to about 1454. Heterogeneity is largely confined to the N-terminal residues, about the first 350 amino acids. Another moderately heterologous region is located between about amino acids 450 to about 650. The sensitizing regions on the coronavirus S gene for these as well as other species coronaviruses are predicted to lie within the regions of antigenicity mapped between avirulent FECV and virulent FIPV.

One potential sensitizing region is a major neutralizing site in the area of amino acid residues #525-650 of TGEV. This antigenic site (A) is conformation- and glycosylation-dependent. This region has a high degree of secondary structure (6 cysteines) and must be expressed in a heterologous vector as a contiguous large protein and not as small peptides. Because this antigenic site is exposed on the surface of TGEV, it is anticipated to be exposed on the FIPV peplomer and other coronavirus S peplomers as well. Thus this sequence and its analogous sequences on FECV, FIPV, CCV and other coronaviruses is a desirable S protein fragment for use in a chimeric protein of this invention.

Another major antigenic site (B) on TGEV which may be a sensitizing region was mapped to amino acids #350-550 and #1170-1190. Again, because of the conservation of amino acids, FIPV, FECV and other coronaviruses are anticipated to contain an antigenic site in these regions. Thus, these sequences are another desirable region for an S protein fragment for use in a chimeric protein of this invention.

In addition, other suitable fragments of a feline, canine or a related coronavirus may be used in a chimeric molecule of the invention. For example, the S protein regions corresponding to, or homologous to, the published WT WSU-1146 amino acid residues are desirable fragments to chimeric proteins: from residues 542-597, which is homologous to the TGEV "A" antigenic site at amino acid 537-592; residues 344-386, which is homologous to the TGEV "B" antigenic site at amino acid 96-144; residues 139-151 and residues 377-386, which is homologous to the TGEV "C" antigenic site at amino acid residues 44-57 and residues 160-173; residues 1426-1438 and residues 1409-1418, which is homologous to the TGEV "D" antigenic site at amino acid residues 378-390 and residues 1173-1184; residues 1344-1404, which is the leucine zipper motif, and residues 1-350 and residues 400-650, which are regions of heterology. Because these sites are antigenic and were mapped by monoclonal antibodies, they are suspected to be B cell sites.

While not wishing to be bound by theory, the inventors propose that antibodies to all or some of these sites may contribute to the immune sensitization characteristic of FIPV infection. By analogy with TGEV, only some of the antigenic sites on FIPV S induce the formation of virus neutralizing antibodies. Since virus neutralization (VN) is often important to controlling virus replication, induction of VN antibodies may be important for clearing infecting virus and may not contribute to sensitization. Antibodies to the non-neutralizing antigenic epitopes, then, may be responsible for exacerbation of disease. Conversely, it may be found that the VN sites contribute to sensitization. In such a case, they may be provide desirable regions for deletion from a chimeric S gene of the invention.

If any humoral response to the FIPV S protein exacerbates disease, recombinant FIPV molecules containing epitopes which do not stimulate antibody production but rather induce T cell immunity are beneficial to safe vaccine formulation. Thus other selected S fragments suitable for use in chimeric S proteins of this invention may be identified by conventional computer programs which predict T cell sites on a protein using several parameters.

Analysis of the DF2-FIPV spike predicted good T cell sites at amino acid residues #77-89, 408-427, 482-496, 922-934, 1133-1147, 1308-1322, and 1379-1391. The majority of the T cell sites lie within the C-terminus of the surface glycoprotein. The other coronavirus are expected to have T cell sites in approximately these regions.

Sequence analysis of all coronavirus S proteins published or identified herein, regardless of host species, indicates that a stretch of amino acids from about 1115 to about 1238 in DF2, FECV, and TS sequences (about 1113 to about 1236 in TGE, and FIPV and from about amino acid #985 to about amino acid 1108 of CCV) is highly conserved. This region lies near the transmembrane domain of the spike protein and may be involved with receptor binding or stalk formation. Its conservation suggests that it plays a major role in virus structure and/or replication. Thus, this fragment of the S gene proteins of the above-identified coronavirses is also expected to be an immunogenic fragment. As such, it may be used in the chimeric proteins of this invention if it is found to be non-sensitizing. If found to be sensitizing, the region may be the site of a deletion.

Additional B and T cell sites can be predicted based upon analogy to the published WT WSU 1146 and TGEV sequences. Regions homologous to these published sequences exist in the feline, canine, and related coronavirus strains and can be determined by one of skill in the art given the fragments and information provided in the present application, and its parent application.

For example, these fragments may be selected from previously amplified regions of feline coronaviruses. The amplification procedure is described in more detail in co-owned, co-pending U.S. Patent Application Ser. No. 07/698,927, which is incorporated by reference herein. Exemplary regions include the following sequences from WT DF2: amino acids #1-105, 1-223, 1-362, 1-555, 1-748, 94-223, 94-362, 94-555, 94-748, 213-362, 213-555, 213-748, 352-748, 737-1454, 894-1040, 894-1203, 894-1454, 1029-1203 and 1029-1454. Similar regions can be identified in the FIPV strains TS DF2, WT WSU 1146, WT UCD-1, WT TN406, WT UCD-4, and in FECV and other related coronaviruses.

Presently, in the production of a chimeric protein of this invention, it is desirable that the fused peptide or protein fragments selected from at least two heterologous species coronaviruses make up a full-length S gene, from amino acid residue 1 to about amino acid residue 1454. Thus, in a preferred embodiment, a chimeric protein of the invention comprises one or more protein or peptide segments of FIPV fused in frame to one or more protein or peptide segments of FECV to form a full length, chimeric S gene.

One such chimeric protein is formed by the fusion of an S gene protein fragment from amino acid #1-352 of the FIPV S protein to the carboxy terminal amino acids #353-1454 of FECV S protein. Another such chimeric is the N terminal fragment of the FECV S protein (from about amino acid #1-352) fused to the carboxy terminal protein sequence (amino acid #353-1454) of FIPV. These chimeric constructs are illustrated in Example 2 below.

In another alternative, the chimeric proteins of the invention consist of a fragment of the FIPV S protein inserted into the FECV S protein to replace a homologous fragment thereof, so that both the amino and carboxy terminal regions are FIPV S protein fragments. In still another alternative, the reverse construct can be made, so that both the amino and carboxy terminal S protein fragments are FECV S gene protein fragments. Such chimeric constructs are illustrated in Example 5 below. Particularly suitable regions include the B cell sites at amino acid residues 542-597, 344-386, 139-151, 44-57 and 160-173, 1426-1438 and 1409-1418, and 1344-1404 of a feline or canine coranovirus, or other regions which have previously been identified as corresponding to antigenic sites in the published TGEV seqeunce. Thus, an exemplary full-length chimeric S gene may comprise FECV amino acids 1-541 fused to FIPV 542-597 fused to FECV 598-1454. Other chimerics may be constructed by inserting one or more of the above-identifed amino acid regions from one coronavirus into the corresponding region of another coronavirus.

Other full-length chimeric S proteins of the invention can be made using any of the feline coronavirus strains identified herein or by substituting any of the other species coronaviruses for either coronavirus S protein fragment of the constructs described above.

In still another embodiment, a chimeric S protein may contain less than a full length S protein. Such a protein may comprise one or more T cell sites, as identified above, fused to one or more B cell sites. These FECV B cell sites have been determined, as described above, by comparison to the neutralizing sites identified in TGEV. For example, a truncated chimeric S protein of the invention may comprise FIPV amino acids 1-352 fused to one or more of the following amino acid regions 77-89, 408-427, 482-496, 922-934, 1133-1147, 1308-1322, and 1379-1391. Because these T cell regions are derived largely from the conserved C terminus, it is expected that a strong cross-species T cell responses will be elicited, particularly when the T cell site is fused to a B cell site. Thus, it is expected that even if these B and T cells sites are from the same coronavirus strain, the truncated chimeric will elicit a cross-species response.

The truncated chimerics of the invention further comprise shortened S proteins, containing a deletion corresponding to one or more of the B cell sites, sensitizing regions, or other non-critical fragments of the S protein identified herein. Alternatively, a chimeric S gene protein of the invention may be truncated at the amino or carboxyl termini of the S proteins, provided that the immunogenicity of the S gene protein is not lost. For example, it may be desirable to remove the transmembrane domain of the S gene in order to facilate secretion of the protein into the extracellular medium and to facilitate purification. Exemplary truncated S proteins may include FECV amino acids 1-542, fused to FIPV 597-1494, having a deletion in the region of 542-597; FECV amino acids 1-138, fused to

CCV amino acids 152-376, fused to FECV amino acids 387-1454, having a deletion in the regions of 139-151 and 377-386; CCV amino acids 1-343 fused to amino acids 1405-1454, having a deletion in the regions of 1344-1404; and FIPV amino acids 351-399 fused to FIPV amino acids 651-1492, having a deletion in the regions of amino acids 1-350 and 400-650.

In another embodiment of the invention, the truncated chimeric S proteins of the invention or the feline coronavirus protein fragment found at amino acids 1115-1238 and described in more detail below, may be fused in frame to a fusion partner, e.g, a larger, carrier molecule. The fusion partner may be a preferred signal sequence, a sequence which is characterized by enhanced secretion in a selected host cell system, or a sequence which enhances the stability of the S-derived peptide. Such exemplary fusion partners include, without limitation, ubiquitin and α mating factor for yeast expression systems, and beta-galactosidase and influenza NS-1 protein for bacterial systems. One of skill in the art can readily select an appropriate fusion partner. The present invention is not limited to the use of any particular fusion partner.

The S protein fragments of the chimeric proteins and the 1115-1238 coronavirus protein fragment may optionally be fused to each other or to a fusion partner through a conventional linker sequence, i.e., containing about 2 to 50 amino acids, and more preferably, about 2 to about 20 amino acids in length. This optional linker may provide space between the two linked sequences. Alternatively, this linker sequence may encode, if desired, a polypeptide which is selectively cleavable or digestible by conventional chemical or enzymatic methods. For example, the selected cleavage site may be an enzymatic cleavage site, including sites for cleavage by a proteolytic enzyme, such as enterokinase, factor Xa, trypsin, collagenase and thrombin. Alternatively, the cleavage site in the linker may be a site capable of being cleaved upon exposure to a selected chemical, e.g., cyanogen bromide or hydroxylamine. The cleavage site, if inserted into a linker useful in the fused sequences of this invention, does not limit this invention. Any desired cleavage site, of which many are known in the art, may be used for this purpose.

Another aspect of this invention provides an S protein region from about amino acid 1115 to about amino acid 1238. It is anticipated that recombinant expression of the highly conserved protein fragment #1115-1238, as described in Examples 11 and 12, may result in the production of a recombinant protein capable of disrupting virus infection in vivo. Thus, a chimeric protein containing this fragment from any of the coronaviruses fused to another selected S fragment is expected to be effective against all coronaviruses, regardless of host specificity or disease etiology. Alternatively, the protein fragment may be useful as an active ingredient in a vaccine component either alone, when fused to a larger, carrier or immunogenic protein, or in combination with other antigens.

In addition to the amino acid sequences and corresponding nucleotide sequences of the specifically-recited embodiments of chimeric proteins of this invention which are described herein, the invention also encompasses other DNA and amino acid sequences of the chimeric proteins of this invention. For example, allelic variations (naturally-occurring base changes in the species population which may or may not result in an amino acid change) of DNA sequences encoding the various S gene amino acid or DNA sequences from the illustrated coronaviruses are also included in the present invention, as well as analogs or derivatives thereof. Similarly, DNA sequences which code for protein sequences of the invention but which differ in codon sequence due to the degeneracies of the genetic code or variations in the DNA sequence encoding these proteins which are caused by point mutations or by induced modifications to enhance the activity, half-life or production of the peptide encoded thereby are also encompassed in the invention.

Variations in the amino acid sequences of this invention may typically include analogs that differ by only 1 to about 4 codon changes. Other examples of analogs include polypeptides with minor amino acid variations from the natural amino acid sequence of S gene proteins and/or the fusion partner; in particular, conservative amino acid replacements. Conservative replacements are those that take place within a family of amino acids that are related in their side chains. Genetically encoded amino acids are generally divided into four families: (1) acidic = aspartate, glutamate; (2) basic = lysine, arginine, histidine; (3) non-polar = alanine, valine, leucine, isoleucine, proline, phenylalanine, methionine, tryptophan; and (4) uncharged polar = glycine, asparagine, glutamine, cysteine, serine, threonine, tyrosine. Phenylalanine, tryptophan, and tyrosine are sometimes classified jointly as aromatic amino acids. For example, it is reasonable to expect that an isolated replacement of a leucine with an isoleucine or valine, an aspartate with a glutamate, a threonine with a serine, or a similar conservative replacement of an amino acid with a structurally related amino acid will not have a significant effect on its activity, especially if the replacement does not involve an amino acid at an epitope of the polypeptides of this invention.

The truncated chimeric proteins or coronavirus fragments thereof of the invention may be prepared by chemical synthesis techniques. Preferably, however, they are prepared by known recombinant DNA techniques by cloning and expressing within a host microorganism or cell a DNA fragment carrying a coding sequence for the selected chimeric protein. Coding sequences for the S gene protein fragments and other viral proteins, e.g., fusion partners, of the coronaviruses can be prepared synthetically or can be derived from viral RNA by known techniques, or from available cDNA-containing plasmids.

Systems for cloning and expressing the vaccinal polypeptide in various microorganisms and cells, including, for example, E. coli, Bacillus, Streptomyces, Saccharomyces, mammalian, yeast and insect cells, and suitable vectors therefor are known and available from private and public laboratories and depositories and from commercial vendors. Currently, the most preferred host is a mammalian cell, such as Chinese Hamster ovary cells (CHO) or COS-1 cells. These hosts may be used in connection with poxvirus vectors, such as vaccinia or swinepox. The selection of other suitable host cells and methods for transformation, culture, amplification, screening and product production and purification can be performed by one of skill in the art by reference to known techniques. See, e.g., Gething and Scambrook, Nature, 293:620-625(1981). Another preferred system includes the baculovirus expression system advectors. While not preferred, E. coli may also be used for production of S protein fragments, where the proper glycosylation and configuration is found to be achieved.

When produced by conventional recombinant means, the chimeric proteins may be isolated either from the cellular contents by conventional lysis techniques or from cell medium by conventional methods, such as chromatography. See, e.g., Sambrook et al, Molecular Cloning. A Laboratory Manual., 2d Edit., Cold Spring Harbor Laboratory, New York (1989).

The resulting chimeric proteins may be screened for efficacy as a vaccine or therapeutic agent in an animal model system involving challenging animals immunized with vaccinia recombinants expressing a selected coronovirus' gene products with the virulent [Vennema et al, J. Virol., 64:1407-1409 (1990)].

Thus, the present invention provides vaccine compositions containing a chimeric or recombinant coronavirus S protein of the invention. Such a vaccine composition may contain such a chimeric S gene protein according to the invention or an immunogenic fragment thereof, together with a carrier suitable for administration as a composition for prophylactic treatment of coronavirus infections.

The chimeric S protein of the invention or immunogenic fragments thereof can be employed in a vaccine composition containing additional antigens, e.g. other chimeric or recombinant coronavirus S gene proteins of the invention, other proteins from the applicable coronavirus, or other proteins or peptides from other pathogens. For example, a vaccine composition containing a FIPV/FECV chimeric S protein may be formulated to further contain the temperature sensitive FIPV vaccine described in detail in co-owned, co-pending U.S. Patent Application Ser. No. 07/428,796 filed October 30, 1989 [SKB 14393], incorporated by reference herein. Alternatively, such a vaccine may also contain, e.g. antigens directed against feline leukemia. Other suitable feline antigens include rabies, feline calici virus, chlamydia, feline immunodeficiency virus, feline parvovirus and feline rhinotracheitis. For chimerics which will be used to vaccinate pigs, other suitable antigens include, for example, pseudorabies, porcine parvovirus, and bacterial antigens. For chimerics which wi be used to vaccinate dogs, other suitable antigens in ie, among others, rabies, canine distemper, Borrelia bu orferi, canine bordtula, canine parvovirus, canine rotavirus, canine parainfluenza, canine adenovirus, and Heptosporidia species.

The preparation of a pharmaceutically acceptable vaccine composition, having appropriate pH isotonicity, stability and other conventional characteristics is within the skill of the art. Thus such vaccines may optimally contain other conventional components, such as adjuvants and/or carriers, e.g. aqueous suspensions of aluminum and magnesium hydroxides, liposomes and the like.

The vaccine composition containing a coronavirus chimeric S protein according to the invention or an immunogenic fragment thereof may be employed to vaccinate naive animals against at least the clinical symptoms associated with the coronaviruses from which the chimeric protein was derived. For example, an FIPV/CCV chimeric is useful in vaccinating against infection with FIP or canine coronavirus. However, it is anticipated that the chimerics of the invention will also provide cross-species protection against coronavirus infection. The vaccines according to the present invention can be administered by an appropriate route, e.g., by the oral, intranasal, subcutaneous, intraperitoneal or intramuscular routes. The presently preferred methods of administration are the subcutaneous and intranasal routes.

The amount of the chimeric coronavirus S protein of the invention present in each vaccine dose is selected with regard to consideration of the animal's age, weight, sex, general physical condition and the like. The amount required to induce an immunoprotective response in the animal without significant adverse side effects may vary depending upon the recombinant protein employed as immunogen and the optional presence of an adjuvant. Generally, it is expected that each dose will comprise 0.05-5000 micrograms of protein per mL, and preferably 0.1-100 micrograms per mL of a sterile solution of an immunogenic amount of a protein or peptide of this invention. Initial doses may be optionally followed by repeated boosts, where desirable.

The invention also provides a pharmaceutical composition comprising the chimeric coronavirus S proteins prepared according to the present invention and a pharmaceutically effective carrier. Suitable pharmaceutically effective carriers for internal administration are known to those skilled in the art. One selected carrier is sterile saline. Other anti-viral agents can also be employed in compositions for the treatment rather than prophylaxsis of coronavirus infection. The pharmaceutical composition can be adapted for administration by any appropriate route, but is designed preferentially for administration by injection or intranasal administration.

Another vaccine agent of the present invention is an anti-sense RNA sequence generated to a sequence of a chimeric protein. This sequence may easily be generated by one of skill in the art either synthetically or recombinantly. Under appropriate delivery, such an anti-sense RNA sequence when administered to an infected animal should be capable of binding to the RNA of a selected coronavirus, thereby preventing viral replication in the cell.

The present invention provides antibodies to a selected chimeric S protein or S protein fragment, such as FIPV amino acid sequence form about residue 1115 to about residue 1238. This antibody may be generated using conventional techniques for production of monoclonal [W. D. Huse et al, Science, 246:1275-1281 (1989); Kohler and Milstein] or polyclonal antibodies.

For diagnostic purposes, the antibodies may be associated with individual labels, and where more than one antibody is employed in a diagnostic method, the labels are desirably interactive to produce a detectable signal. Most desirably, the label is detectable visually, e.g. colorimetrically. Detectable labels for attachment to antibodies useful in the diagnostic assays of this invention may also be easily selected by one skilled in the art of diagnostic assays. Labels detectable visually are preferred for use in clinical applications due to the rapidity of the signal and its easy readability. For colorimetric detection, a variety of enzyme systems have been described in the art which will operate appropriately. Colorimetric enzyme systems include, e.g., horseradish peroxidase (HRP) or alkaline phosphatase (AP). Other proximal enzyme systems are known to those of skill in the art, including hexokinase in conjunction with glucose-6-phosphate dehydrogenase. Also, bioluminescence or chemiluminescence can be detected using, respectively, NAD oxidoreductase with luciferase and substrates NADH and FMN or peroxidase with luminol and substrate peroxide. Other conventional label systems that may be employed include fluorescent compounds, radioactive compounds or elements, or immunoelectrodes. These and other appropriate label systems and methods for coupling them to antibodies or peptides are known to those of skill in the art.

Antibodies may also be used therapeutically as targeting agents to deliver virus-toxic or infected cell-toxic agents to infected cells. Rather than being associated with labels for diagnostic uses, a therapeutic agent employs the antibody linked to an agent or ligand capable of disabling the replicating mechanism of the virus or of destroying the virally-infected cell. The identity of the toxic ligand does not limit the present invention. It is expected that preferred antibodies to peptides encoded by the chimeric S genes identified herein or the FIPV peptide located at amino acids 1115-1238 may be screened for the ability to internalize into the infected cell and deliver the ligand into the cell.

The present invention also provides a diagnostic kit which enables distinction between native coronavirus exposure and animals vaccinated with the chimeric or recombinant molecules of the invention. Such a kit may contain a sufficient amount of at least one chimeric S protein, either full-length or truncated or at least one recombinant S protein of the invention and such components as are necessary to practise the assay. Such assays are conventional, and the necessary reagents and other components of such a kit are well known to those of skill in the art.

The following examples illustrate preferred methods for preparing chimeric molecules of the invention. These examples are illustrative only and do not limit the scope of the invention. For instance, although these examples utilize FECV, another avirulent or non-sensitizing coronavirus, i.e. FIPV strain UCD-2, CCV, TGEV, PRCV, BCV, or AVC could be used in its place in these chimerics. In addition, Type I FIPV sequences (i.e., TN406) may be substituted for WT DF2 FIPV (Type II) to expand cross-strain protection.

Example 1 - PCR Amplification

A. Source of Cells and Viruses

Norden Laboratories Feline Kidney (NLFK) [Christianson et al, Arch. Virol., 109:185-196 (1989)] cells were grown in Basal Medium Eagle (BME) supplemented with 5% fetal bovine serum (FBS) and 10 mM Hepes. For vaccinia virus infections, human thymidine-kinase-negative (HuTKO) [ATCC CRL 8303] and African green monkey kidney (CV-1) cell lines [ATCC CCL 70] were used and maintained in Dulbecco's modified Eagle's medium (DMEM) containing 10% fetal bovine serum.

The DF2 wildtype FIPV virus was originally isolated at SBAH, Lincoln, from a cat liver explant. After several passages of tissue homogenates in specific pathogen free (SPF) cats, the virus was adapted to NLFK cells by cocultivation with infected primary spleens and later plaque-purified. A feline enteric coronavirus, FECV (WSU-1683), was obtained from Washington State University. Vaccinia virus strain WR was received from Dr. Bernard Moss, NIH.

B. Oligonucleotide Design and Synthesis

The DF2 FIPV spike gene sequence contained a <u>Pst</u>I site at amino acid 352 while the FECV spike gene did not. Oligonucleotide primers were specifically designed to allow PCR amplification of FECV spike protein amino acid regions 1-352 and 352-1454. PCR primers were 30-40 base pairs in length and included an <u>Sma</u>I site in the upstream (5') primer and a <u>Pst</u>I site in the downstream (3') primer (1-352 amino acid) and a <u>Pst</u>I in the upstream primer and a <u>Stu</u>I in the downstream primer (352-1454 amino acid). These sites were incorporated into the primers to allow the reconstruction of full-length chimeric FECV/FIPV S genes through ligation of the <u>Pst</u>I sites. Oligonucleotide primers were synthesized on an Applied Biosystem Model 380B DNA Synthesizer using the phosphoramidite method. The primers were gel-purified prior to use. The primers used are as follows.

The top/left strand PCR primer specific for FECV, and contains XmaI, but not 5 bp 5' matching sequence: SEQ ID NO:
5'-CCCGGGCATG ATTGTGCTCG TAACTTGCC TCTTGTTGTTA TGC.

Also a top/left strand PCR primer specific for FECV, the following primer contains additional stabilizing sequence (GTGC from the published sequence upstream of the ATG) upstream of the SmaI/XmaI site to help with digestion of the end.
SEQ ID NO:
5'-GTGCCCCGGG CATGATTGTG CTCGTAACTT GCCTCTTGTT GTTATGC.

The following two primers are FECV Pst primers and are used to regenerate the PstI site in FECV which does not result in an amino acid change when compared to the WT WSU 1146 published strain. These primers contain the PstI site (bp 1104-1146) in the middle and contain one FECV specific base pair. The top strand primer is:
SEQ ID NO:
5'- CAATCTTAAT TTCACTGCAG ATGTACAATC TGGTATGGGT GCT,
and is used with the StuI bottom primer. The bottom strand primer is:
SEQ ID NO:
5'- AGCACCCATA CCAGATTGTA CATCTGCAGT GAAATTAAGA TTG,
and is used with the XmaI top primer.

The following FECV Pst primers are also useful in regenerated the PstI site in FECV which does not result in an amino acid change when compared to the WSU strain. The top strand primer containing the PstI site (bp 1118-1146) is SEQ ID NO: 5'-CTGCAGATGT ACAATCTGGT ATGGGTGCT, and is used with the StuI bottom primer. The bottom strand primer containing the PstI site (bp 1094-1122) is SEQ ID NO: CTGCAGTGAA ATTAAGATTG AATCTAATA, and is used with the XmaI top primer.

Also useful is the following table of primers which were identified in the parent application (Ser. No. 07/698,927).

TABLE I

5' (sequence [illegible] published WSU 1146, contains Xma site)

Position (BP)	Position (AA)	Sequence
5' Xma/3' Xma		
65-69/70-96(Start) SEQ ID NO:	1-9	Xma GTGCCCCCGGGTATGATTGTGCTCGTAACTTGCCTCTTG start codon
351-355/356-380 SEQ ID NO:	95-104	AATACCCGGGCACTGGTAATGCACGTGGTAAACC
705-709/710-733 SEQ ID NO:	213-219	GTATTCCCGGGCACGCTCAAGCACTGCTACCTGGG
1121-1125/1126-1150 SEQ ID NO:	352-360	CAGATCCCGGGGTACAATCTGGTATGGGTGCTACAG
1698-1702/1703-1730 SEQ ID NO:	544-554	GCTTACCCGGGGTGGTTATGGTCAACCCATAGCCTCGAC
2277-2281/2282-2309 SEQ ID NO:	737-746	TGTGACCCGGGCGCCATGTGATGTAAGCGCACAAGCGGC
2749-2753/2754-2779 SEQ ID NO:	894-903	GCAATCCCGGGGGGTGCCAGACTTGAAAACATGGAGG
3155-3159/3160-3185 SEQ ID NO:	1030-1038	CATTACCCGGGGGTGCACTTGGTGGTGGCGCCGTGGC
3642-3646/3647-3674 SEQ ID NO:	1192-1201	TAGGTCCCGGGCTCAGTCTCAGAGATTCGGATTCTGTGG

3' (sequence reverse complement of published WSU 1146, contains Stu I site)

Position (BP)	Position (AA)	Sequence
5' StuI/3' Stu I		
385-381/380-356 SEQ ID NO:	97-105	Stu I ATAATAGGCCTGGTTTACCACGTGCATTACCAGTGC
738-734/733-710 SEQ ID NO:	213-223	GTATTAGGCCTCCCAGGTAGCAGTGCTTGAGCGTG
1155-1151/1150-1126 SEQ ID NO:	353-362	AAATAAGGCCTCTGTAGCACCCATACCAGATTGTAC
1735-1731/1730-1703 SEQ ID NO:	546-555	TTAGTAGGCCTGTCGAGGCTATGGGTTGACCATAACCAC
2314-2310/2309-2282 SEQ ID NO:	739-748	TAACAAGGCCTGCCGCTTGTGCGCTTACATCACATGGCG
2784-2780/2779-2754 SEQ ID NO:	896-905	ATCAAAGGCCTCCTCCATGTTTTCAAGTCTGGCACCC
3190-3186/3185-3160 SEQ ID NO:	1031-1040	GTATAAGGCCTGCCACGGCGCCACCACCAAGTGCACC
3679-3675/3674-3647 SEQ ID NO:	1194-1203	CATTAAGGCCTCCACAGAATCCGAATCTCTGAGACTGAG
4433-4429/4428-4405(Stop) SEQ ID NO:	1444-1452	TAAATAGGCCTTTAGTGGACATGCACTTTTTCAATTGG * stop codon

C. RNA Purification

Roller bottles of confluent NLFK cells were infected with either FIPV or FECV virus using the following protocol. The growth medium was removed and virus (MOI = 0.1) was adsorbed in 50 ml of BME supplemented with 2% FBS. FIPV infections were performed in serum-free medium. The virus was absorbed for 2 hours and then 250 ml of growth medium added. The cultures were monitored for cytopathic effect (CPE) and typically harvested at 24-36 hours post-infection. Total cytoplasmic RNA was prepared from the infected monolayers by guanidine isothiocyanate extraction [Chirgwin et al, Biochem., 18:5294 (1979)].

D. Generation of PCR amplified fragments

All PCR reagents were produced by Perkin Elmer-Cetus (Norwalk, CT). PCR amplified fragments were generated using the following procedure. Synthesis of cDNA from total RNA isolated from cells infected with a specific coronavirus was performed for each virus.

In a final reaction volume of 20 μl of 1X PCR buffer (10X PCR buffer; 100 mM Tris-HCl, 500 mM KCl, 15 mM $MgCl_2$, 0.01% (w/v) gelatin), the following components were assembled in RNAse free siliconized 500 μl microcentrifuge tubes: 1.0 mM of each dNTP, 20 units of RNAsin (Promega Corporation, Madison, WI), 100 picomoles of random hexamer oligonucleotides (Pharmacia, Milwaukee, WI), 100 picomoles/μl solution in TE buffer (10 mM Tris-HCl, 1 mM EDTA, pH 7.5), 200 units of reverse transcriptase (Moloney MuLV, Bethesda Research Labs, Gaithersburg, MD) and 1.0 μg of respective RNA isolated as described above. To avoid pipetting errors and contamination, all solutions were aliquoted from master mixes made with diethyl pyrocarbonate (DEPC) treated water and consisted of all of the reaction components except the RNA which was added last. The mixture was incubated in a programmable thermal cycler (Perkin-Elmer Cetus, Norwalk, CT) at 20°C for ten minutes followed by 42°C for one hour then 95°C for five minutes and finally held at 4°C until PCR amplification.

Amplification of the cDNA was performed essentially according to the method of Saiki et al, Science, 230:1350-1354 (1985) using the Taq polymerase. Briefly, to the 20 µl CDNA reaction mix from above was added: 8.0 µl 10X PCR buffer, 1.0 µl of each upstream and downstream primer previously diluted in water to 30 picomoles per microliter and 5.0 units of Taq polymerase (Perkin-Elmer Cetus, Norwalk, CT). Final volume was made up to 100 µl of mineral oil. As above, master mixes were prepared to avoid contamination. The reaction was performed in the Perkin-Elmer Cetus thermal cycler for one cycle by denaturing at 95°C for 1 minute, annealing at 37°C for 2' followed by an extension at 72°C for 40 minutes. This initial cycle increased the likelihood of first strand DNA synthesis. A standard PCR profile was then performed by a 95°C-1 minutes denaturation, 37°C-2 minutes annealing, 72°C-3 minutes extension for 40 cycles. A final extension cycle was done by 95°C-1 minutes denaturation, 37°C-2 minutes annealing, 72°C-15 minutes extension and held at 4°C until analyzed.

E. Analysis of PCR products

PCR products were analyzed by electrophoresing 5.0 µl of the reaction on a 1.2% agarose gel run 16-17 hours. Amplified fragments were purified prior to use for cloning by column chromatography with the PrimeEase Quick method (Stratagene, LaJolla, CA). Bands were visualized by ethidium bromide staining the gel and fluorescence by UV irradiation at 256 nm. Photography using Polaroid type 55 film provided a negative that could be digitized for sample distance migration and comparison against markers run on each gel. The actual sizes of the bands were then calculated using the Beckman Microgenie software running on an IBM AT.

Example 2 - Cloning of Full-length DF2 FIPV and FECV S

For use in assays, a full length WT DF2 FIPV S [SEQ ID NO: 2] was employed as a positive control for sensitization; and a full length FECV S [SEQ ID NO: 12] was employed as a negative control for sensitization. Full length DF2 FIPV and FECV S genes were cloned in vaccinia vector pSC11 [Chakrabari *et al*, *Mol. and Cell Biol.*, 5:3403-3409 (1985)], as follows.

A. pSC11

Cloning procedures were as described by Sambrook et al, cited above (1989) and all plasmids were transformed into the *E. coli* host strain, HB101. pSC11 is a vector designed to allow expression of a cloned gene of interest inserted into an unique *Sma*I site downstream of the p7.5 promoter of vaccinia virus. pSC11 contains vaccinia TK-gene sequences for homologous recombination into the virus and the amp gene for selection in *E. coli*. This vector also contains the p11 vaccinia virus promoter regulating the *E. coli* lacZ gene. Expression from this promoter results in the synthesis of beta-galactosidase protein. Recombinant viruses containing the pSC11 plasmid will therefore appear as blue plaques in the presence of X-gal or Bluo-gal [Sigma]. All clones are introduced into the *Sma*I site of this vector as blunt-ended fragments and the resulting clones oriented with respect to the p7.5 promoter.

B. Cloning

The *E. coli*-derived vector, pOTSKF33, was chosen for cloning. Cloning procedures were as described by Sambroook et al, cited above. The bacterial expression vector, pOTSKF33, shown schematically in Figure 1 of the parent application, is being maintained at SmithKline Beecham Laboratories and is available to the public through the company.

This plasmid is a derivative of pBR322 [Bethesda Research Laboratories] and carries regulatory signals from bacteriophage lambda. The system provides a promoter which can be controlled (λP_L), and an antitermination mechanism to ensure efficient transcription across any gene insert, high vector stability, antibiotic selection, and flexible sites for insertion of any gene downstream of the regulatory sequences. The pOTSKF33 vector also contains the coding sequence for 52 amino acids of the enzyme galactokinase, immediately adjacent to the λP_L promoter. The sequence of this enzyme has been manipulated to permit insertion of foreign genes and the construction of fusion proteins.

Linkers containing restriction sites for fusion in any of the three reading frames, stop codons for each frame and some additional cloning sites for fusion in any of the three reading frames, have been introduced after the first 52 amino acids of galactokinase.

Transcription from the P_L promoter is tightly controlled by maintaining the plasmid in bacteria expressing the $c1^+$ repressor protein. Induction of foreign protein expression is obtained by removing the repressor. In the bacterial strains used in this study, the repressor protein is temperature-sensitive. At the permissive temperature, 32°C, the repressor functions normally to inhibit transcription from the P_L regulatory sequences. An increase in growth temperature (to 42°C) results in degradation of the repressor and expression of the fusion polypeptide is induced.

Full-length DF2 FIPV and FECV spike gene 1-1454 amino acid inserts were isolated from established pOTSKF33 plasmid clones (as described in the above-identified parent application, incorporated by reference herein), by SmaI/StuI digestion of plasmid DNA and the excised gene cloned into the pSC11/SmaI vector using conventional techniques. Insert-bearing clones were identified by BamHI digest of mini-prep DNA. Full-length clones were oriented with respect to vector by digestion with XbaI (FECV) and NcoI (FIPV).

Example 3 - Cloning of Chimeric 1-352/353-1454 amino acid FIPV/FECV S genes in pSC11

Full length chimeric S genes were engineered to encode (a) 1-352 amino acid [SEQ ID NO: 19] of FECV fused to 353-1454 amino acid [SEQ ID NO: 20] of WT DF2 FIPV [SEQ ID NO: 21]; and (b) 1-352 amino acid [SEQ ID NO: 22] of WT DF2 FIPV fused to 353-1454 amino acid [SEQ ID NO: 23] of FECV [chimeric S gene SEQ ID NO: 24].

DF2 FIPV SmaI/PstI 1-352 [SEQ ID NO: 22] and PstI/StuI 353-1454 [SEQ ID NO: 20] amino acid DNA inserts were also isolated from an established pOTSKF33 plasmid containing the full-length FIPV spike gene as follows. PCR-amplified FECV DNAs representing amino acid regions 1-352 [SEQ ID NO: 19] and 353-1454 [SEQ ID NO: 23] were digested with SmaI/PstI (30°C) and PstI/StuI (37°C), respectively, for 18 hours. Digests were loaded onto 1% low-melting temperature agarose gels prepared and run in Tris-Borate-EDTA buffer. DNA fragments were isolated and eluted as described by Sambrook et al, cited above, (1989).

Briefly, DNA fragments were visualized after staining with ethidium bromide, excised from the gel with a scalpel and transferred to microfuge tubes. Gel slices were incubated for 5 minutes at 65°C, vortexed, and 5 volumes of 20 mM Tris, pH 8.0, 1 mM EDTA were added. Samples were incubated an additional 2 minutes at 65°C and were then extracted once with phenol and again with phenolchloroform. The DNA was precipitated with 1/10 volume 3 M NaOAc, pH 7.0, and 2.5 volumes of cold 95% EtOH overnight at -20°C. DNAs were pelleted, resuspended in reagent-quality water, and ligated together overnight at 15°C. Ligation products were then ligated to pSC11 vector which had previously been digested with <u>Sma</u>I and dephosphorylated.

Host cells [ATCC HB101] were transformed and ampicillin-resistant colonies selected. Insert-bearing clones were identified by <u>Bam</u>HI digest of mini-prep DNA. Full-length clones were oriented with respect to the vector and verified for the presence of amino acid #352 by <u>Pst</u>I digest.

The presence of FIPV and FECV specific insert regions in the chimeric clones were identified by diagnostic restriction enzyme digestions: (1) 1-352 amino acid FIPV [SEQ ID NO: 22], <u>Nco</u>I; (2) 353-1454 amino acid FIPV [SEQ ID NO: 20], <u>Xba</u>I; (3) 1-352 amino acid FECV [SEQ ID NO: 19], <u>Xba</u>I; and (4) 353-1454 amino acid FECV [SEQ ID NO: 23], <u>Xmn</u>I. Restriction enzymes were purchased from New England Biolabs (Beverly, MA) or Bethesda Research Labs (Gaithersburg, MD) and used according to manufacturer's specifications.

Alternatively, chimeric S genes were first isolated in pOTSKF33 or pBluescript SK_{μ}M13 vectors and then subsequently re-isolated from plasmid DNA for cloning into pSC11/<u>Sma</u>I vector.

<u>Example 4 - Cloning of Chimeric 1-352/353-870/871-1454 amino acid FIPV/FECV S Genes in pSC11</u>

Chimerics having 1-352 DF2 FIPV fused to 353-870 FECV fused to 870-1454 FIPV are identified by SEQ ID NO: 30. Chimerics having 1-352 FECV fused to 353-870 DF2 FIPV, fused to 871-1454 FECV, as identified herein by SEQ ID NO: 30. DF2 FIPV and FECV <u>Sma</u>I/<u>Pst</u>I 1-352 amino acid

[SEQ ID NO: 22 and 19, respectively] and PstI/BstEII (nt 2618) 353-870 amino acid [SEQ ID NO: 25 and 26, respectively] and BstEII/StuI 871-1454 amino acid [SEQ ID NO: 27 and 28, respectively] DNA inserts were also isolated from an established pOTSKF33 plasmid containing the full-length FIPV and FECV (+ PstI site) spike gene.

The isolated fragments were then ligated with pSC11/SmaI overnight at 15°C. Insert-bearing clones were identified by BamHI digest of mini-prep DNA. Full-length clones were oriented with respect to the 7.5 K promoter in the vector and verified for presence of swapped 352-870 amino acid by BsmI or XmnI digest (present in FECV but not in FIPV at nt 1800 or 2560, respectively). The presence of FIPV and FECV specific insert regions in the chimeric clones were identified by diagnostic restriction enzyme digestions: (1) 1-352 amino acid FIPV [SEQ ID NO: 22], NcoI; (2) 871-1454 amino acid FIPV [SEQ ID NO: 27], XbaI; (3) 1-352 amino acid FECV [SEQ ID NO: 19], PflMI; and (4) 871-1454 amino acid FECV [SEQ ID NO: 28], PleI.

Example 5 - Cloning of T-Cell Rich Regions in pSC11: FIPV 894-1040 amino acid

The following example demonstrates that the amino acid region from 894-1040 is rich in T-cell sites, which are capable of stimulating an immune response.

FIPV SmaI/StuI inserts were isolated from an established plasmid [pOTSKF33] containing the 894-1040 amino acid region [SEQ ID NO: 31] of the DF2 FIPV spike gene. The isolated fragments were purified using GeneClean (Bio 101 Inc., LaJolla, CA) according to the manufacturer's instructions. Purified inserts were ligated with pSC11-SmaI phosphatased vector overnight at 15°C. Insert-bearing clones were identified by BamHI digest of mini-prep DNA. Full-length clones were oriented with respect to the 7.5K promoter in the vector by DraIII, XhoI/DraIII, and BamHI/DraIII digest. PCR DNAs representing DF2 S FIPV 894-1203 amino acid [SEQ ID NO: 32] were purified using Prime Erase Quik Columns (Stratagene Cloning Systems, LaJolla, CA). PCR DNAs were then digested SmaI/StuI, isolated on agarose gels, and purified with GeneClean. Purified inserts were ligated to pSC11/SmaI vector overnight at 15°C. Full length clones were identified by BamHI digest of mini-prep DNA and oriented with respect to vector by HindIII and XhoI/HindIII digests.

Example 6 - Recombinant Expression of Predicted T Cell Sites Alone

As described in the parent and grandparent of the present application, previous experiments with an *E. coli* fusion protein containing WT DF2 FIPV 894-1040 amino acid induced a cellular immune response in mice and protected 50% of cats from FIPV challenge. Therefore, the following recombinant viruses were made to determine whether or not a cell mediated immune response could be selectively stimulated by immunizing cats with one or more of the predicted major T cell sites on the S gene expressed in vaccinia virus recombinants.

Recombinant vaccinia viruses were engineered to contain selected regions of the WT DF2 S gene encoding the predicted FIPV T cell sites: (a) 894-1040 amino acid (predicted to contain T cell sites at 922-934 amino acid); and (b) 894-1203 amino acid (the above clone was expanded to add strong T cell site at residues 1133-1147).

Example 7 - Generation of Recombinant Vaccinia Viruses

Standard vaccinia virus transfection procedures were used to isolate recombinant viruses expressing full length DF2 FIPV, FECV, selected portions of the FIPV S and chimeric FIPV/FECV spike genes [D. M. Glover, DNA Cloning, A Practical Approach, Volume 2, IRL Press, (1985)]. Briefly, plasmid DNA prepared from partial (Example 6), full-length (Example 3) or chimeric S (Examples 4 and 5)/pSC11 clones was used to transfect CV-1 [ATCC CCL 70] monolayers infected with the WR strain of vaccinia virus. Transfected monolayers were harvested 2 days post-infection (p.i.) and were plaque-assayed on HuTK-cell [ATCC CRL 8303] monolayers in 60 mm dishes. At 3 days p.i. dishes were stained with an agarose overlay containing 300 μg/ml Bluo-gal [Sigma]. After 4 hours, blue ßGal+ plaques were identified and picked with sterile Pasteur pipettes into 0.5 ml DMEM + 5% fetal bovine serum. First-round plaques were plaque-purified twice more on HuTK- cells and then used to infect CV-1 and HuTK- monolayers in T25 flasks. Infected monolayers were harvested at 2 days p.i. and frozen at -20°C for use as crude virus stocks.

Example 8 - Characterization of Recombinant Vaccinia Viruses

The presence of DNA in 3X plaque-purified virus stocks was verified by DNA dot blot, using standard methods [D. M. Glover, DNA Cloning, A Practical Approach, Volume 2, IRL Press, (1985)]. Expression of recombinant S genes was evaluated by Western blot. HuTK- monolayers infected with recombinant viruses were harvested at 2 days p.i. by scraping into the medium. Pelleted cells were washed with PBS and resuspended in 0.6 ml RIPA buffer (0.15 M NaCl, 0.1% SDS, 1.0% Na deoxycholate, 1.0% Triton X-100, 5mM EDTA, 20 mM Tris, pH 7.4). RIPA lysates were frozen/thawed 3X and sonicated briefly. Non-reducing sample buffer (2% SDS, 80 mM Tris, pH 6.8, 10% glycerol, 0.02% bromophenol blue) was added and samples boiled 10 minutes prior to electrophoresis on 10%

SDS-polyacrylamide gels as described by Laemmli. Proteins were transferred to Immobilon-P (Millipore) at 20-25 mA for 18 hours in Tris/Glycine/Methanol buffer. Filters were blocked in 2% skim milk, 1% gelatin, and TBS (20 mM Tris, pH 7.5, 500 mM NaCl) for 1-2 hours (h) at room temperature (RT), rinsed with TTBS (TBS + 0.05% Tween-20) and incubated with anti-FIPV cat serum at a 1:50 dilution in TTBS and 1% gelatin for 1-2 hours at RT.

Anti-FIPV serum was produced at SBAH, Lincoln, in cats that were vaccinated two times intranasally with Primucell (SmithKline Beecham) vaccine containing a temperature-sensitive DF2 FIPV at three week intervals and challenged orally with 1 mL DF2 FIPV two weeks following the third vaccination. Animals were then bled by conventional means.

Filters were washed in TTBS 3X for 10 minutes each and incubated with goat anti-cat alkaline-phosphatase labeled IgG at a 1:1000 dilution for 1 hours [Kirkegaard-Perry Laboratories, Inc.]. Filters were washed as before and incubated 5-15 minutes in BCIP/NBT substrate according to the manufacturer's instructions [Kirkegaard-Perry Laboratories, Inc.]. Filters were then rinsed in water and air-dried.

Example 9 - Cats Immunized with Vaccinia Recombinants Expressing Chimeric FECV/FIPV S Genes

To evaluate immunogenicity of these molecules, recombinant vaccinia viruses expressing FIPV S (v/FIPV S), FECV S (v/FECV S), or FIPV/FECV chimeric S genes (v/FIPV + FECV S) are used to immunize kittens. 14-week-old specific pathogen free kittens, eight per group, are immunized subcutaneously with 2 X 10^7 PFU of the recombinant vaccinia/FIPV viruses. A group of eight kittens receives the same amount of wild-type WR vaccinia virus (v/WR) as a negative control. Kittens are clinically examined daily and rectal temperatures taken. A second immunization with the same amount of virus is given after 3 weeks. Two weeks after the second immunization kittens are challenged orally with 5 X 10^5 PFU of WT DF2 FIPV and survival monitored. Virus-neutralization titers are determined on the day of challenge and one and two weeks post-challenge. Serum samples are taken on the days of first and second vaccination, challenge, and post-challenge days 3, 7, 14, 21, and 28.

The results are predicted below:

Group	Cat/group	Innoculum	Sensitization
Group 1	8	WR/FECV S	No
Group 2	8	WR/FIPV S	Yes
Group 3	8	WR/FIPV-FECV Chimera	Yes
Group 4	8	WR/FECV/FIPV	No
Group 5	8	WR vaccinia	No

Example 10 - Chimeric FECV/FIPV Genes

By analogy with TGEV, the predicted location of the major neutralizing epitope on the feline coronavirus S is ~ amino acids 525-650. To evaluate the role of the neutralizing epitope in immunity to FIPV, full-length 'chimeric' S proteins were constructed in which amino acids 352-870 of FIPV are replaced by the analogous region of FECV or conversely, amino acids 352-870 of FECV are interchanged for amino acids 352-870 of FIPV.

Full length S proteins which contain: (a) 1-352 amino acid of FECV fused to 353-870 amino acid of WT DF2 FIPV fused to 871-1454 amino acid of FECV; and (b) 1-352 amino acid of WT DF2 FIPV fused to 353-870 amino acid of FECV fused to 871-1454 amino acid of WT DF2 FIPV were engineered.

Alternate cloning sites between amino acids 650 and 870 amino acid could be used in place of BstEII (i.e., PvuII, HgaI) to excise the middle portion of the S gene encompassing the VN epitope(s).

Example 11- CCV S 1-128 aa

The established pOTSKF33 plasmid, described above, containing a full-length chimeric CCV/FIPV S gene was used to provide sequence analysis of 1-128aa of the CCV spike gene. This plasmid contains 1-352aa and 352-1452aa of the CCV and DF2 FIPV spike genes, respectively, ligated together to reconstruct a full length chimeric spike gene as follows. Briefly, 10 µl of a PCR DNA representing CCV S protein amino acids 1-362 was digested with XmaI/PstI and ligated overnight at 15°C to a PstI/StuI 352-1452aa purified insert fragment isolated from a DF2 FIPV spike gene plasmid. The DF2 FIPV S gene clone from which 352-1454 amino acid PstI and StuI insert was isolated and cloned by digesting a PCR DNA containing DF2 FIPV S 1-1454 amino acid with XmaI and StuI. Ligation products were then ligated for 4 hours at room temperature to pOTSKF33 vector [SmithKline Beecham Pharmaceuticals, Swedeland, PA], digested with XmaI/StuI and dephosphorylated. Transformants in *E. coli* strain AR120 [SmithKline Beecham] were screened by BamHI and SphI digests of mini prep DNAs to identify insert-bearing clones.

Ligation products of the CCV and DF2 FIPV ligation were ligated into pOTSK33 vectors under similar conditions to these described above, digested with XmaI/StuI and dephosphorylated. AR120 transformants were screened by BamHI/SphI and PstI digests of mini prep DNAs. The presence of an unique StuI site at amino acid #128 of CCV S gene was confirmed by StuI digest. Clone #2324 was identified as containing a full length chimeric spike gene containing regions 1-352aa of CCV and 352-1452aa of FIPV.

Example 12 - Cloning of Coronavirus Conserved Region in pMG1

The vector pMG1 allows the gene expressing a foreign protein to be fused to a partial sequence of the NS1 gene from the influenza virus the first 81 encoding amino acids thereof. This vector is derived as follows. Plasmid pAPR801 is a pBR322-derived cloning vector which carries the NS1 coding region (A/PR/8/34). It is described by Young et al, in The Origin of Pandemic Influenza Viruses, 1983, edited by W. G. Laver, Elsevier Science Publishing Co.

Plasmid pAS1 is a pBR322-derived expression vector which contains the P_L promoter, an N utilization site (to relieve transcriptional polarity effects in the presence of N protein) and the cII ribosome binding site including the cII translation initiation codon followed immediately by a BamHI site. It is described by Rosenberg et al, Methods Enzymol., 101:123-138 (1983).

Plasmid pAS1deltaEH was prepared by deleting a non-essential EcoRI-HindIII region of pBR322 origin from pAS1. A 1236 base pair BamHI fragment of pAPR801, containing the NS1 coding region in 861 base pairs of viral origin and 375 base pairs of pBR322 origin, was inserted into the BamHI site of pAS1deltaEH. The resulting plasmid, pAS1deltaEH/801 expresses authentic NS1 (230 amino acids). This plasmid has an NcoI site between the codons for amino acids 81 and 82 and an NruI site 3' to the NS sequences. The BamHI site between amino acids 1 and 2 is retained.

Plasmid pMG27N a pAS1 derivative [Mol. Cell Bio., 5:1015-1024 (1985)], was cut with BamHI and SacI and ligated to a BamHI/NcoI fragment encoding the first 81 amino acids of NS1 from pAS1ΔEH801 and a synthetic DNA NcoI/SacI fragment of the following sequence:

SEQ ID NO: 33:
5'-CATGGATCATATGTTAACAGATATCAAGGCCTGACTGACTGAGAGCT-3'

SEQ ID NO: 34:
3'- CTAGTATACAATTGTCTATAGTTCCGGACTGACTGACTC -5'

The resulting plasmid is pMG1.

Primers were designed to amplify a region encompassing amino acids 1115-1238 of the DF2 FIPV strain for expression in this vector as follows. The upstream primer contains NcoI and NdeI restriction sites and initiates amplification at base pair 3406 (amino acid 1113). SEQ ID NO:

5'-
GTTGTCAACACACCATGGATCATATGCAAGGGCAAGCTTTAAGTCACCTTACA
NcoI NdeI

The downstream primer contains a StuI site and terminates amplification at base pair 3777 (amino acid 1236). SEQ ID NO:

5'-AAATACCTGAGGCCTCCAAGCTGTTACAGTTTCATAAGCTGT
StuI

The amplified fragment (412 bp) was purified using the Prime Erase Quik column method (Stratagene, LaJolla, CA). It was digested with NcoI/StuI and ligated overnight at 15°C to plasmid vector pMG1 digested with NcoI/StuI.

The presence of insert bearing clones were confirmed by diagnostic restriction enzyme digestions. The conserved regions will also be cloned into the vaccinia expression vector, pSC11 by blunt-ending the 412 NcoI/StuI fragment and inserting it into the SmaI site downstream of the 7.5K vaccinia promoter. Full-length clones were identified and oriented with respect to vector by BamHI and ScaI digests of mini-prep DNAs, respectively. Expression was characterized using antibodies produced by immunizing rabbits with the *E. coli* produced fusion protein containing the NS1/FIPV conserved region.

Example 13 - Conserved Domain of Coronavirus S

A region of amino acids near the transmembrane domain of the S gene was identified which is highly conserved among all coronaviruses, regardless of species specificity or disease etiology. In bovine coronaviruses, this region is implicated in stalk formation and antibodies to this region inhibit fusion. In order to determine whether or not a strong immune response to this region interferes with the normal biological function of the spike protein, preventing infection and spread of the virus or if because of its conserved nature, a recombinant vaccine comprising this region induces immunity to many coronaviruses of significance to both human and animal health, the following study was performed.

Vaccinia recombinants were engineered to contain the 1115-1238 amino acid conserved region of WT DF2 FIPV.

Numerous modifications and variations of the present invention are included in the above-identified specification and are expected to be obvious to one of skill in the art. Such modifications and alterations to the compositions and processes of the present invention are believed to be encompassed in the scope of the claims appended hereto.

What is claimed is:

1. A chimeric coronavirus S protein or fragment thereof comprising a first S protein fragment from a first selected coronavirus strain and a second S protein fragment, from a second selected coronavirus strain, said protein capable of eliciting an immune response in a host animal to a selected coronavirus.

2. The protein according to Claim 1 characterized by the ability to elicit an immune response to more than one or more species of coronavirus.

3. The chimeric coronavirus S protein or fragment thereof according to claim 1 wherein said chimeric protein contains additional S protein fragments capable of eliciting an immune response.

4. The chimeric coronavirus S protein or fragment thereof according to claim 1 wherein first and second coronaviruses are selected from the group consisting of a Type I FIPV strain, a Type II FIPV strain, a Type I and Type II FIPV strain, a FECV strain, a CCV strain, a TGEV strain, a PRCV strain, an avian coronavirus, and a murine coronavirus.

5. The chimeric coronavirus S gene or fragment thereof according to claim 4 wherein said FIPV strain coronavirus is selected from the group consisting of WT FIPV DF2, WT FIPV WSU 1146, TS FIPV, WT FIPV UCD-2, WT FIPV TN406, WT FIPV UCD-1, FIPV DF2-HP, and FIPV TS-BP.

6. The chimeric coronavirus S protein or fragment thereof according to claim 4 wherein said first protein is selected from the group consisting of amino acid residues 77-89, 408-427, 482-496, 922-934, 1133-1147, 1308-1322, 1379-1391, 352-1454, 1-352, 870-1454, 897-1040, 894-1203, and 1115-1236 of an FIPV strain.

7. The chimeric coronavirus S protein or fragment thereof according to claim 6 wherein said FIPV strain is WT FIPV DF2.

8. The chimeric coronavirus S protein or fragment thereof according to claim 6 wherein the second protein is from a FECV strain, whereby the two proteins together form a full length S gene.

9. The chimeric coronavirus S protein or fragment thereof according to claim 4 wherein said first protein is selected from the group consisting of amino acid residuas 525-650, 350-550, and 1170-1190 of a selected coronavirus strain.

10. The chimeric coronavirus S protein or fragment thereof according to claim 1 wherein said first protein fragment is a B cell site and wherein said second protein fragment is a T cell site, said chimeric being less than a full-length S gene.

11. The chimeric coronavirus S protein or fragment thereof according to claim 10 wherein said T cell site is selected from the group of coronavirus strain amino acid residues consisting of 77-89, 408-427, 482-496, 922-934, 1133-1147, 1308-1322, and 1379-1391.

12. The chimeric coronavirus S protein or fragment thereof according to claim 9 wherein said B cell site is selected from the group of amino acid residues consisting of 542-597, 344-386, 139-151 and 377-386, 1426-1438 and 1409-1418, 1344-1404 and 1-350 and 400-650 of an selected coronavirus strain.

13. A chimeric coronavirus S protein selected from the group consisting of

(a) amino acids 1-352 of a FIPV strain fused to amino acids 353-1454 of a FECV strain,

(b) amino acids 1-352 of a FECV strain fused to amino acids 353-1454 of a FIPV strain,

(c) amino acids 1-352 of a FECV strain fused to amino acids 353-870 of a FIPV strain fused to amino acids 871-1454 of a FECV strain, and

(d) amino acids 1-352 of a FIPV strain fused to amino acids 353-870 of a FECV strain fused to amino acids 871-1454 of a FIPV strain.

14. A recombinant protein useful in immunizing cats against infection with FIPV comprising amino acids amino acids 1115-1238 of a FIPV strain.

15. A protein useful in the treatment or prophylaxis of a disease caused by a coronavirus comprising a selected sequence from a chimeric coronavirus S protein or fragment thereof comprising a first protein fragment capable of eliciting an immune response in a host animal to a first selected coronavirus strain and a second protein fragment capable of eliciting an immune response in a host animal to a selected coronavirys, wherein said chimeric is capable of eliciting an immune response to more than one or more species of coronavirus.

16. A DNA sequence useful in the treatment or prophylaxis of a disease caused by a coronavirus comprising a selected nucleotide sequence encoding a chimeric coronavirus S protein or fragment thereof.

17. The DNA sequence acording to claim 16 comprising a sequence spanning nucleotide numbers 1 to 1454 of said S gene.

18. A vaccine composition comprising an immunogenic amount of a chimeric coronavirus S protein or fragment thereof.

19. The vaccine composition according to claim 16 further comprising one or more additional antigens.

20. The vaccine composition according to claim 16 comprising a dose unit of 0.05 micrograms to 5000 micrograms per mL of a sterile solution of said chimeric coronavirus S gene.

21. A method for vaccinating a naive animal against a cornonavirus which comprises internally administering to the animal an effective immunogic amount of a chimeric coronavirus S gene or fragment thereof.

22. A pharmaceutical composition for treating coronavirus infection in an animal comprising an effective amount of a chimeric coronavirus S protein or fragment thereof.

23. An antibody to a chimeric coronavirus S protein or fragment thereof comprising amino acids 1115-1236 of an FIPV strain.

24. A diagnostic kit for distinguishing between natural exposure and animals vaccinated with a chimeric coronavirus of the invention comprising a chimeric coronavirus S protein or fragment thereof or a nucleotide sequence encoding said protein or fragment.

25. A recominant S protein comprising an amino acid sequence spanning amino acid residue 1115 to 1236 on an FIPV strain.

(3)

Abstract

The present invention provides a chimeric coronavirus S protein or fragment thereof useful in vaccinal and therapeutic compositions comprising two or more S proteins or peptides from more than one coronavirus species fused in frame, said peptide or protein from a FIPV, TGEV, PRCV, FECV, BCV, avian coronavirus, murine coronavirus, human coronavirus or CCV strain.

#3

DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled COMPOSITIONS AND METHODS FOR VACCINATION OF CATS AGAINST FELINE CORONAVIRUSES the specification of which

(check one)		is attached hereto
	X	was filed on May 8, 1992 as Application Serial No. 07/882,171 and was amended on ________. (if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is known to me to be material to patentability under Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s)

(Number)	(Country)	(Day/Month/Year Filed)	Priority Claimed Yes	No

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, Section 112, I acknowledge the duty to disclose information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application:

(Application Serial No.)	(Filing Date)	(Status) (patented, pending, abandoned)
07/698,927	May 13, 1991	Pending
07/613,066	November 14, 1990	Pending

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

1-00

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FIGURE 1

DF2 FIPV, nucleotides 1 - 4365 [SEQ ID NO:]
DF2 FIPV, amino acid 1 - 1454 [SEQ ID NO:]

DF2-HP, nucleotides* 1 - 2246 [SEQ ID NO:]
DF2-HP, amino acids* 1 - 748 [SEQ ID NO:]

```
ATG ATT GTG CTC GTA ACT TGC CTC TTG TTG TTA TGT      36
Met Ile Val Leu Val Thr Cys Leu Leu Leu Leu Cys
 1               5                  10

TCA TAC CAC ACA GTT TTG AGT ACA ACA AAT AAT GAA      72
Ser Tyr His Thr Val Leu Ser Thr Thr Asn Asn Glu
        15                  20

TGC ATA CAA GTT AAC GTA ACA CAA TTG GCT GGC AAT     108
Cys Ile Gln Val Asn Val Thr Gln Leu Ala Gly Asn
 25                  30                  35

GAA AAC CTT ATC AGA GAT TTT CTG TTT AGT AAC TTT     144
Glu Asn Leu Ile Arg Asp Phe Leu Phe Ser Asn Phe
            40                  45

AAA GAA GAA GGA AGT GTA GTT GTT GGT GGT TAT TAC     180
Lys Glu Glu Gly Ser Val Val Val Gly Gly Tyr Tyr
    50                  55                  60

                                             T*
CCT ACA GAG GTG TGG TAC AAC TGC TCT AGA ACA GCA     216
Pro Thr Glu Val Trp Tyr Asn Cys Ser Arg Thr Ala
                65                  70

 G*
CAA ACT ACT GCC TTT CAG TAT TTT AAT AAT ATA CAT     252
Gln Thr Thr Ala Phe Gln Tyr Phe Asn Asn Ile His
Arg*    75                  80

GCC TTT TAT TTT GTT ATG GAA GCC ATG GAA AAT AGC     288
Ala Phe Tyr Phe Val Met Glu Ala Met Glu Asn Ser
 85                  90                  95

ACT GGT AAT GCA CGT GGT AAA CCA TTA TTA TTT CAT     324
Thr Gly Asn Ala Arg Gly Lys Pro Leu Leu Phe His
 ↑          100                 105
97 of WSU 1146
FIPV in 58-3;
AR58-3 amino acid #62

GTG CAT GGT GAG CCT GTT AGT GTT ATT ATA TAT ATA     360
Val His Gly Glu Pro Val Ser Val Ile Ile Tyr Ile
    110                 115                 120
```

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Figure [illegible] (cont'd)

```
TCG GCT TAT AGG GAT GAT GTG CAA CAA AGG CCC CTT    396
Ser Ala Tyr Arg Asp Asp Val Gln Gln Arg Pro Leu
            125                 130

    G*
TTA AAA CAT GGG TTA GTG TGC ATA ACT AAA AAT CGC    432
Leu Lys His Gly Leu Val Cys Ile Thr Lys Asn Arg
    Glu*135                 140

CAT ATT AAC TAT GAA CAA TTC ACC TCC AAC CAG TGG    468
His Ile Asn Tyr Glu Gln Phe Thr Ser Asn Gln Trp
145                     150 ↑       ↑   155
                         AR58-3     AR58-3
                       a.a. #116    a.a. #118

AAT TCC ACA TGT ACG GGT GCT GAC AGA AAA ATT CCT    504
Asn Ser Thr Cys Thr Gly Ala Asp Arg Lys Ile Pro
        160                     165

TTC TCT GTC ATA CCC ACG GAC AAT GGA ACA AAA ATC    540
Phe Ser Val Ile Pro Thr Asp Asn Gly Thr Lys Ile
    170                 175                 180

TAT GGT CTT GAG TGG AAT GAT GAC TTT GTT ACA GCT    576
Tyr Gly Leu Glu Trp Asn Asp Asp Phe Val Thr Ala
            185                 190

TAT ATT AGT GGT CGT TCT TAT CAC TTG AAC ATC AAT    612
Tyr Ile Ser Gly Arg Ser Tyr His Leu Asn Ile Asn
        195               ↑ 200
                        AR58-3
                      a.a. #164

ACT AAT TGG TTT AAC AAT GTC ACA CTT TTG TAT TCA    648
Thr Asn Trp Phe Asn Asn Val Thr Leu Leu Tyr Ser
205                 210                 215

CGC TCA AGC ACT GCT ACC TGG GAA TAC AGT GCT GCA    684
Arg Ser Ser Thr Ala Thr Trp Glu Tyr Ser Ala Ala
            220                 225

TAT GCT TAC CAA GGT GTT TCT AAC TTC ACT TAT TAC    720
Tyr Ala Tyr Gln Gly Val Ser Asn Phe Thr Tyr Tyr
    230                 235                 240

AAG TTA AAT AAC ACC AAT GGT CTA AAA ACC TAT GAA    756
Lys Leu Asn Asn Thr Asn Gly Leu Lys Thr Tyr Glu
                245                 250

TTA TGT GAA GAT TAT GAA CAT TGC ACT GGC TAT GCT    792
Leu Cys Glu Asp Tyr Glu His Cys Thr Gly Tyr Ala
        255                 260
```

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FIGURE 1 (cont'd)

```
ACC AAT GTA TTT GCT CCG ACA TCA GGT GGT TAC ATA     828
Thr Asn Val Phe Ala Pro Thr Ser Gly Gly Tyr Ile
265                 270                 275

                          T*
CCT GAT GGA TTT AGT TTT AAC AAT TGG TTC TTG CTT     864
Pro Asp Gly Phe Ser Phe Asn Asn Trp Phe Leu Leu
            280                 285

ACA AAT AGT TCC ACT TTT GTT AGT GGC AGG TTT GTA     900
Thr Asn Ser Ser Thr Phe Val Ser Gly Arg Phe Val
    290                 295                 300

ACA AAT CAA CCA TTA TTG ATT AAT TGC TTG TGG CCA     936
Thr Asn Gln Pro Leu Leu Ile Asn Cys Leu Trp Pro
                305                 310

GTG CCC AGT TTT GGT GTA GCA GCA CAA GAA TTT TGT     972
Val Pro Ser Phe Gly Val Ala Ala Gln Glu Phe Cys
        315                 320

TTT GAA GGT GCA CAG TTT AGC CAA TGT AAT GGT GTG    1008
Phe Glu Gly Ala Gln Phe Ser Gln Cys Asn Gly Val
325                 330                 335

TCT TTA AAT AAC ACA GTG GAT GTT ATT AGA TTC AAC    1044
Ser Leu Asn Asn Thr Val Asp Val Ile Arg Phe Asn
            340                 345

CTT AAT TTC ACT GCA GAT GTA CAA TCT GGT ATG GGT    1080
Leu Asn Phe Thr Ala Asp Val Gln Ser Gly Met Gly
    350                 355                 360

  C*
GCT ACA GTA TTT TCA CTG AAT ACA ACA GGT GGT GTC    1116
Ala Thr Val Phe Ser Leu Asn Thr Thr Gly Gly Val
                365                 370

ATT CTT GAA ATT TCA TGT TAT AGT GAC ACA GTG AGT    1152
Ile Leu Glu Ile Ser Cys Tyr Ser Asp Thr Val Ser
        375                 380

GAG TCT AGT TCT TAC AGT TAT GGT GAA ATC CCG TTC    1188
Glu Ser Ser Ser Tyr Ser Tyr Gly Glu Ile Pro Phe
385                 390                 395

GGC ATA ACT GAC GGA CCA CGA TAC TGT TAT GTA CTT    1224
Gly Ile Thr Asp Gly Pro Arg Tyr Cys Tyr Val Leu
            400                 405
```

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FIGURE 1 (cont'd)

```
TAC AAT GGC ACA GCT CTT AAA TAT TTA GGA ACA TTA    1260
Tyr Asn Gly Thr Ala Leu Lys Tyr Leu Gly Thr Leu
    410                 415                 420

CCA CCC AGT GTA AAG GAA ATT GCT ATT AGT AAG TGG    1296
Pro Pro Ser Val Lys Glu Ile Ala Ile Ser Lys Trp
                425                 430

GGC CAT TTT TAT ATT AAT GGT TAC AAT TTC TTT AGC    1332
Gly His Phe Tyr Ile Asn Gly Tyr Asn Phe Phe Ser
        435                 440

ACA TTT CCT ATT GGT TGT ATA TCT TTT AAT TTA ACC    1368
Thr Phe Pro Ile Gly Cys Ile Ser Phe Asn Leu Thr
445                 450                 455

         T*
ACT GGT GCT AGT GGA GCT TTT TGG ACA ATT GCT TAC    1404
Thr Gly Ala Ser Gly Ala Phe Trp Thr Ile Ala Tyr
        Val*460                 465

ACA TCG TAT ACT GAA GCA TTA GTA CAA GTT GAA AAC    1440
Thr Ser Tyr Thr Glu Ala Leu Val Gln Val Glu Asn
    470                 475                 480

ACA GCT ATT AAA AAT GTG ACG TAT TGT AAC AGT CAC    1476
Thr Ala Ile Lys Asn Val Thr Tyr Cys Asn Ser His
                485                 490

ATT AAT AAC ATT AAA TGT TCT CAA CTT ACT GCT AAT    1512
Ile Asn Asn Ile Lys Cys Ser Gln Leu Thr Ala Asn
        495                 500

TTG AAT AAT GGA TTT TAT CCT GTT GCT TCA AGT GAA    1548
Leu Asn Asn Gly Phe Tyr Pro Val Ala Ser Ser Glu
505                 510                 515

GTA GGT TTC GTT AAT AAG AGT GTT GTG TTA TTA CCT    1584
Val Gly Phe Val Asn Lys Ser Val Val Leu Leu Pro
            520                 525

                 T*
AGC TTT TTC ACA CAC ACC GCT GTC AAT ATA ACC ATT    1620
Ser Phe Phe Thr His Thr Ala Val Asn Ile Thr Ile
    530         Tyr*    535                 540

GAT CTT GGT ATG AAG CTT AGT GGT TAT GGT CAA CCC    1656
Asp Leu Gly Met Lys Leu Ser Gly Tyr Gly Gln Pro
                545                 550
```

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FIGURE 1 (cont'd)

```
ATA GCC TCG ACA CTA AGT AAC ATC ACA CTA CCA ATG   1692
Ile Ala Ser Thr Leu Ser Asn Ile Thr Leu Pro Met
        555                 560

CAG GAT AAC AAT ACT GAT GTG TAC TGT ATT CGT TCT   1728
Gln Asp Asn Asn Thr Asp Val Tyr Cys Ile Arg Ser
565                 570                 575

                             A*
AAC CAA TTC TCA GTT TAT GTT CCT TCC ACT TGC AAA   1764
Asn Gln Phe Ser Val Tyr Val Pro Ser Thr Cys Lys
            580             His 585

                          C*
AGT TCT TTA TGG GAC AAT ATT TTT AAT CAA GAC TGC   1800
Ser Ser Leu Trp Asp Asn Ile Phe Asn Gln Asp Cys
    590                 595                 600

ACG GAT GTT TTA GAG GCT ACA GCT GTT ATA AAA ACT   1836
Thr Asp Val Leu Glu Ala Thr Ala Val Ile Lys Thr
                605                 610

GGT ACT TGT CCT TTC TCA TTT GAT AAA TTG AAC AAT   1872
Gly Thr Cys Pro Phe Ser Phe Asp Lys Leu Asn Asn
        615                 620

TAC TTG ACT TTT AAC AAG TTC TGT TTG TCG TTG AGT   1908
Tyr Leu Thr Phe Asn Lys Phe Cys Leu Ser Leu Ser
625                 630                 635

CCT GTT GGT GCT AAT TGC AAG TTT GAT GTT GCT GCA   1944
Pro Val Gly Ala Asn Cys Lys Phe Asp Val Ala Ala
            640                 645

CGT ACA AGA ACC AAT GAG CAG GTT GTT AGA AGT CTA   1980
Arg Thr Arg Thr Asn Glu Gln Val Val Arg Ser Leu
    650                 655                 660

TAT GTA ATA TAT GAA GAA GGA GAC AAC ATA GTG GGT   2016
Tyr Val Ile Tyr Glu Glu Gly Asp Asn Ile Val Gly
                665                 670

                G*
GTA CCG TCT GAT AAT AGC GGT CTG CAC GAT TTG TCT   2052
Val Pro Ser Asp Asn Ser Gly Leu His Asp Leu Ser
        675     Asp     680

GTG CTA CAC CTA GAC TCC TGT ACA GAT TAC AAT ATA   2088
Val Leu His Leu Asp Ser Cys Thr Asp Tyr Asn Ile
685                 690                 695
```

FIGURE 1 (cont'd)

```
TAT GGT AGA ACT GGT GTT GGT ATT ATT AGA CGA ACT    2124
Tyr Gly Arg Thr Gly Val Gly Ile Ile Arg Arg Thr
            700                 705

AAC AGT ACG CTA CTT AGT GGC TTA TAT TAC ACA TCA    2160
Asn Ser Thr Leu Leu Ser Gly Leu Tyr Tyr Thr Ser
    710                 715                 720

CTA TCA GGT GAT TTG TTA GGC TTT AAA AAT GTT AGT    2196
Leu Ser Gly Asp Leu Leu Gly Phe Lys Asn Val Ser
                725                 730

GAT GGT GTC ATT TAT TCT GTG ACG CCA TGT GAT GTA    2232
Asp Gly Val Ile Tyr Ser Val Thr Pro Cys Asp Val
        735                 740

AGC GCA CAA GCG GCT GTT ATT GAT GGT GCC ATA GTT    2268
Ser Ala Gln Ala Ala Val Ile Asp Gly Ala Ile Val
745                 750                 755

GGA GCT ATG ACT TCC ATT AAC AGT GAA CTG TTA GGT    2304
Gly Ala Met Thr Ser Ile Asn Ser Glu Leu Leu Gly
            760                 765

CTA ACA CAT TGG ACA ACG ACA CCT AAT TTT TAT TAC    2340
Leu Thr His Trp Thr Thr Thr Pro Asn Phe Tyr Tyr
    770                 775                 780

TAC TCT ATA TAT AAT TAC ACA AGT GAG AGG ACT CGT    2376
Tyr Ser Ile Tyr Asn Tyr Thr Ser Glu Arg Thr Arg
                785                 790

GGC ACT GCA ATT GAC AGT AAC GAT GTT GAT TGT GAA    2412
Gly Thr Ala Ile Asp Ser Asn Asp Val Asp Cys Glu
        795                 800

CCT GTC ATA ACC TAT TCT AAT ATA GGT GTT TGT AAA    2448
Pro Val Ile Thr Tyr Ser Asn Ile Gly Val Cys Lys
805                 810                 815

AAT GGT GCT TTG GTT TTT ATT AAC GTC ACA CAT TCT    2484
Asn Gly Ala Leu Val Phe Ile Asn Val Thr His Ser
            820                 825

GAC GGA GAC GTG CAA CCA ATT AGC ACT GGT AAT GTC    2520
Asp Gly Asp Val Gln Pro Ile Ser Thr Gly Asn Val
    830                 835                 840

ACG ATA CCT ACA AAT TTT ACC ATA TCT GTG CAA GTT    2556
Thr Ile Pro Thr Asn Phe Thr Ile Ser Val Gln Val
                845                 850
```

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FIGURE 1 (cont'd)

```
GAA TAC ATG CAG GTT TAC ACT ACA CCA GTA TCA ATA    2592
Glu Tyr Met Gln Val Tyr Thr Thr Pro Val Ser Ile
        855                 860

GAT TGT GCA AGA TAC GTT TGT AAT GGT AAC CCT AGA    2628
Asp Cys Ala Arg Tyr Val Cys Asn Gly Asn Pro Arg
865                 870                 875

TGT AAC AAA TTG TTA ACA CAA TAT GTG TCT GCA TGT    2664
Cys Asn Lys Leu Leu Thr Gln Tyr Val Ser Ala Cys
            880                 885

CAA ACT ATT GAA CAA GCA CTT GCA ATG GGT GCC AGA    2700
Gln Thr Ile Glu Gln Ala Leu Ala Met Gly Ala Arg
    890                 895                 900

CTT GAA AAC ATG GAG GTT GAT TCC ATG TTG TTT GTC    2736
Leu Glu Asn Met Glu Val Asp Ser Met Leu Phe Val
                905                 910

TCG GAA AAT GCC CTT AAA TTG GCA TCT GTT GAG GCG    2772
Ser Glu Asn Ala Leu Lys Leu Ala Ser Val Glu Ala
        915                 920

TTC AAT AGT ACA GAA AAT TTA GAT CCT ATT TAC AAA    2808
Phe Asn Ser Thr Glu Asn Leu Asp Pro Ile Tyr Lys
925                 930                 935

GAA TGG CCT AGC ATA GGT GGT TCT TGG CTA GGA GGT    2844
Glu Trp Pro Ser Ile Gly Gly Ser Trp Leu Gly Gly
            940                 945

CTA AAA GAT ATA CTA CCG TCC CAT AAT AGC AAA CGT    2880
Leu Lys Asp Ile Leu Pro Ser His Asn Ser Lys Arg
    950                 955                 960

AAG TAT GGT TCT GCT ATA GAA GAT TTG CTT TTT GAT    2916
Lys Tyr Gly Ser Ala Ile Glu Asp Leu Leu Phe Asp
                965                 970

AAA GTT GTA ACA TCT GGT TTA GGT ACA GTT GAT GAA    2952
Lys Val Val Thr Ser Gly Leu Gly Thr Val Asp Glu
        975                 980

GAT TAT AAA CGT TGT ACT GGT GGT TAC GAC ATA GCA    2988
Asp Tyr Lys Arg Cys Thr Gly Gly Tyr Asp Ile Ala
985                 990                 995

GAC TTG GTG TGT GCT CAA TAT TAC AAT GGC ATC ATG    3024
Asp Leu Val Cys Ala Gln Tyr Tyr Asn Gly Ile Met
            1000                1005
```

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FIGURE 1 (cont'd)

```
GTT CTA CCA GGT GTA GCT AAT GCT GAC AAG ATG ACT    3060
Val Leu Pro Gly Val Ala Asn Ala Asp Lys Met Thr
    1010                1015                1020

ATG TAC ACA GCA TCA CTT GCA GGT GGT ATA ACA TTA    3096
Met Tyr Thr Ala Ser Leu Ala Gly Gly Ile Thr Leu
                1025                1030

GGT GCA CTT GGT GGT GGC GCC GTG GCT ATA CCT TTT    3132
Gly Ala Leu Gly Gly Gly Ala Val Ala Ile Pro Phe
        1035                1040

GCA GTA GCA GTA CAG GCT AGA CTT AAT TAT GTT GCT    3168
Ala Val Ala Val Gln Ala Arg Leu Asn Tyr Val Ala
1045                1050                1055

CTA CAA ACT GAT GTA TTG AAT AAA AAC CAA CAG ATC    3204
Leu Gln Thr Asp Val Leu Asn Lys Asn Gln Gln Ile
            1060                1065

CTG GCT AAT GCT TTC AAT CAA GCT ATT GGT AAC ATT    3240
Leu Ala Asn Ala Phe Asn Gln Ala Ile Gly Asn Ile
    1070                1075                1080

ACA CAG GCT TTT GGT AAG GTT AAT GAT GCT ATA CAT    3276
Thr Gln Ala Phe Gly Lys Val Asn Asp Ala Ile His
                1085                1090

CAA ACA TCA CAA GGT CTT GCC ACT GTT GCT AAA GCG    3312
Gln Thr Ser Gln Gly Leu Ala Thr Val Ala Lys Ala
        1095                1100

TTG GCA AAA GTG CAA GAT GTT GTC AAC ACA CAA GGG    3348
Leu Ala Lys Val Gln Asp Val Val Asn Thr Gln Gly
1105                1110                1115

CAA GCT TTA AGT CAC CTT ACA GTA CAA TTG CAA AAT    3384
Gln Ala Leu Ser His Leu Thr Val Gln Leu Gln Asn
            1120                1125

AAT TTT CAA GCC ATT AGT AGT TCT ATT AGT GAT ATT    3420
Asn Phe Gln Ala Ile Ser Ser Ser Ile Ser Asp Ile
    1130                1135                1140

TAT AAC AGG CTT GAC GAA CTG AGT GCT GAT GCA CAA    3456
Tyr Asn Arg Leu Asp Glu Leu Ser Ala Asp Ala Gln
                1145                1150

GTT GAT AGG CTG ATT ACA GGT AGA CTT ACA GCA CTT    3492
Val Asp Arg Leu Ile Thr Gly Arg Leu Thr Ala Leu
        1155                1160
```

FIGURE 1 (cont'd)

AAT GCA TTT GTG TCT CAG ACT CTA ACC AGA CAA GCA 3528
Asn Ala Phe Val Ser Gln Thr Leu Thr Arg Gln Ala
1165 1170 1175

GAG GTT AGG GCT AGT AGA CAA CTT GCC AAA GAC AAG 3564
Glu Val Arg Ala Ser Arg Gln Leu Ala Lys Asp Lys
1180 1185

GTT AAT GAA TGT GTT AGG TCT CAG TCT CAG AGA TTC 3600
Val Asn Glu Cys Val Arg Ser Gln Ser Gln Arg Phe
1190 1195 1200

GGA TTC TGT GGT AAT GGT ACA CAT TTG TTT TCA CTA 3636
Gly Phe Cys Gly Asn Gly Thr His Leu Phe Ser Leu
1205 1210

GCA AAT GCA GCA CCA AAT GGC ATG ATT TTC TTT CAT 3672
Ala Asn Ala Ala Pro Asn Gly Met Ile Phe Phe His
1215 1220

ACA GTA CTA TTA CCA ACA GCT TAT GAA ACT GTA ACA 3708
Thr Val Leu Leu Pro Thr Ala Tyr Glu Thr Val Thr
1225 1230 1235

GCT TGG TCA GGT ATT TGT GCT TCA GAT GGC GAT CGC 3744
Ala Trp Ser Gly Ile Cys Ala Ser Asp Gly Asp Arg
1240 1245

ACT TTC GGA CTT GTC GTT AAA GAT GTG CAG TTG ACG 3780
Thr Phe Gly Leu Val Val Lys Asp Val Gln Leu Thr
1250 1255 1260

TTG TTT CGT AAT CTA GAT GAC AAG TTC TAT TTG ACC 3816
Leu Phe Arg Asn Leu Asp Asp Lys Phe Tyr Leu Thr
1265 1270

CCC AGA ACT ATG TAT CAG CCT AGA GTT GCA ACT AGT 3852
Pro Arg Thr Met Tyr Gln Pro Arg Val Ala Thr Ser
1275 1280

TCT GAT TTT GTT CAA ATT GAA GGG TGT GAT GTG TTG 3888
Ser Asp Phe Val Gln Ile Glu Gly Cys Asp Val Leu
1285 1290 1295

TTT GTC AAC GCG ACT GTA ATT GAT TTG CCT AGT ATT 3924
Phe Val Asn Ala Thr Val Ile Asp Leu Pro Ser Ile
1300 1305

ATA CCT GAC TAT ATT GAC ATT AAT CAA ACT GTT CAA 3960
Ile Pro Asp Tyr Ile Asp Ile Asn Gln Thr Val Gln
1310 1315 1320

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FIGURE 1 (cont'd)

```
GAC ATA TTA GAA AAT TAC AGA CCA AAC TGG ACT GTA   3996
Asp Ile Leu Glu Asn Tyr Arg Pro Asn Trp Thr Val
                1325                1330

CCT GAA TTT ACA CTT GAT ATT TTC AAC GCA ACC TAT   4032
Pro Glu Phe Thr Leu Asp Ile Phe Asn Ala Thr Tyr
        1335                1340

TTA AAT CTG ACT GGT GAA ATT GAT GAC TTA GAG TTT   4068
Leu Asn Leu Thr Gly Glu Ile Asp Asp Leu Glu Phe
1345                1350                1355

AGG TCA GAA AAG CTA CAT AAC ACT ACA GTA GAA CTT   4104
Arg Ser Glu Lys Leu His Asn Thr Thr Val Glu Leu
            1360                1365

GCC ATT CTC ATT GAT ACC ATT AAT AAT ACA TTA GTC   4140
Ala Ile Leu Ile Asp Thr Ile Asn Asn Thr Leu Val
    1370                1375                1380

AAT CTT GAA TGG CTC AAT AGA ATT GAA ACT TAT GTA   4176
Asn Leu Glu Trp Leu Asn Arg Ile Glu Thr Tyr Val
                1385                1390

AAA TGG CCT TGG TAT GTG TGG CTA CTG ATA GGT CTA   4212
Lys Trp Pro Trp Tyr Val Trp Leu Leu Ile Gly Leu
        1395                1400

GTA GTA GTA TTT TGC ATA CCA TTA CTG CTA TTT TGC   4248
Val Val Val Phe Cys Ile Pro Leu Leu Leu Phe Cys
1405                1410                1415

TGT TTT AGC ACA GGT TGT TGT GGA TGC ATA GGT TGT   4284
Cys Phe Ser Thr Gly Cys Cys Gly Cys Ile Gly Cys
            1420                1425

TTA GGA AGT TGT TGT CAC TCT ATA TGT AGT AGA AGA   4320
Leu Gly Ser Cys Cys His Ser Ile Cys Ser Arg Arg
    1430                1435                1440

CAA TTT GAA TAT TAT GAA CCA ATT GAA AAA GTG CAT   4356
Gln Phe Glu Tyr Tyr Glu Pro Ile Glu Lys Val His
                1445                1450

GTC CAC TAA                                       4365
Val His
```

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FIGURE 2

TS FIPV, nucleotides 1 - 4365 [SEQ ID NO:]
TS FIPV, amino acids 1 - 1454 [SEQ ID NO:]

TS-BP, nucleotides* 1 - 2246 [SEQ ID NO:]
TS-BP, amino acids* 1 - 748 [SEQ ID NO:]

ATG ATT GTG CTC GTA ACT TGC CTC TTG TTG TTA TGT 36
Met Ile Val Leu Val Thr Cys Leu Leu Leu Leu Cys
1 5 10

TCA TAC CAC ACA GTT TTG AGT ACA ACA AAT AAT GAA 72
Ser Tyr His Thr Val Leu Ser Thr Thr Asn Asn Glu
15 20

A*
TGC ATA CAA GTT AAC GTT ACA CAA TTG GCT GGC AAT 108
Cys Ile Gln Val Asn Val Thr Gln Leu Ala Gly Asn
25 30 35

GAA AAC CTT ATC AGA GAT TTT CTG TTT AGT AAC TTT 144
Glu Asn Leu Ile Arg Asp Phe Leu Phe Ser Asn Phe
40 45

AAA GAA GAA GGA AGT GTA GTT GTT GGT GGT TAT TAC 180
Lys Glu Glu Gly Ser Val Val Val Gly Gly Tyr Tyr
50 55 60

CCT ACA GAG GTG TGG TAC AAC TGC TCT AGA ACA GCT 216
Pro Thr Glu Val Trp Tyr Asn Cys Ser Arg Thr Ala
65 70

CGA ACT ACT GCC TTT CAG TAT TTT AAT AAT ATA CAT 252
Arg Thr Thr Ala Phe Gln Tyr Phe Asn Asn Ile His
75 80

GCC TTT TAT TTT GTT ATG GAA GCC ATG GAA AAT AGC 288
Ala Phe Tyr Phe Val Met Glu Ala Met Glu Asn Ser
85 90 95

ACT GGT AAT GCA CGT GGT AAA CCA TTA TTA TTT CAT 324
Thr Gly Asn Ala Arg Gly Lys Pro Leu Leu Phe His
↑ 100 105
97 of WSU 1146
FIPV in 58-3
corresponds to amino acid #62 of AR58-3

GTG CAT GGT GAG CCT GTT AGT GTT ATT ATA TAT ATA 360
Val His Gly Glu Pro Val Ser Val Ile Ile Tyr Ile
110 115 120

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FIGURE 2 (cont'd)

```
TCG GCT TAT AGG GAT GAT GTG CAA CAA AGG CCC CTT     396
Ser Ala Tyr Arg Asp Asp Val Gln Gln Arg Pro Leu
                125                 130

TTA AAA CAT GGG TTA GTG TGC ATA ACT AAA AAT CGC     432
Leu Lys His Gly Leu Val Cys Ile Thr Lys Asn Arg
        135                 140

CAT ATT AAC TAT GAA CAA TTC ACC TCC AAC CAG TGG     468
His Ile Asn Tyr Glu Gln Phe Thr Ser Asn Gln Trp
145                     150  ↑       ↑      155
                          AR58-3    AR58-3
                        a.a. #116   a.a. #118

AAT TCC ACA TGT ACG GGT GCT GAC AGA AAA ATT CCT     504
Asn Ser Thr Cys Thr Gly Ala Asp Arg Lys Ile Pro
            160                 165

TTC TCT GTC ATA CCC ACG GAC AAT GGA ACA AAA ATC     540
Phe Ser Val Ile Pro Thr Asp Asn Gly Thr Lys Ile
    170                 175                 180

TAT GGT CTT GAG TGG AAT GAT GAC TTT GTT ACA GCT     576
Tyr Gly Leu Glu Trp Asn Asp Asp Phe Val Thr Ala
                185                 190

TAT ATT AGT GGT CGT TCT TAT CAC TTG AAC ATC AAT     612
Tyr Ile Ser Gly Arg Ser Tyr His Leu Asn Ile Asn
        195                 200

ACT AAT TGG TTT AAC AAT GTC ACA CTT TTG TAT TCA     648
Thr Asn Trp Phe Asn Asn Val Thr Leu Leu Tyr Ser
205                 210                 215

CGC TCA AGC ACT GCT ACC TGG GAA TAC AGT GCT GCA     684
Arg Ser Ser Thr Ala Thr Trp Glu Tyr Ser Ala Ala
            220               ↑ 225
                        FIPV amino acid
                      #223 from WSU 1146;
                        AR58-3 a.a. #189

TAT GCT TAC CAA GGT GTT TCT AAC TTC ACT TAT TAC     720
Tyr Ala Tyr Gln Gly Val Ser Asn Phe Thr Tyr Tyr
    230                 235                 240

AAG TTA AAT AAC ACC AAT GGT CTA AAA ACC TAT GAA     756
Lys Leu Asn Asn Thr Asn Gly Leu Lys Thr Tyr Glu
                245                 250

TTA TGT GAA GAT TAT GAA CAT TGC ACT GGC TAT GCT     792
Leu Cys Glu Asp Tyr Glu His Cys Thr Gly Tyr Ala
        255                 260
```

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FIGURE 2 (cont'd)

ACC AAT GTA TTT GCT CCG ACA TCA GGT GGT TAC ATA 828
Thr Asn Val Phe Ala Pro Thr Ser Gly Gly Tyr Ile
265 270 275

CCT GAT GGA TTT AGT TTT AAT AAT TGG TTC TTG CTT 864
Pro Asp Gly Phe Ser Phe Asn Asn Trp Phe Leu Leu
280 285

ACA AAT AGT TCC ACT TTT GTT AGT GGC AGG TTT GTA 900
Thr Asn Ser Ser Thr Phe Val Ser Gly Arg Phe Val
290 295 300

ACA AAT CAA CCA TTA TTG ATT AAT TGC TTG TGG CCA 936
Thr Asn Gln Pro Leu Leu Ile Asn Cys Leu Trp Pro
305 310

C*
GTG CCC AGT TTT GGT GTA GTA GCA CAA GAA TTT TGT 972
Val Pro Ser Phe Gly Val Val Ala Gln Glu Phe Cys
315 Ala*320

TTT GAA GGT GCA CAG TTT AGC CAA TGT AAT GGT GTG 1008
Phe Glu Gly Ala Gln Phe Ser Gln Cys Asn Gly Val
325 330 335

TCT TTA AAT AAC ACA GTG GAT GTT ATT AGA TTC AAC 1044
Ser Leu Asn Asn Thr Val Asp Val Ile Arg Phe Asn
340 345

CTT AAT TTC ACT GCA GAT GTA CAA TCT GGT ATG GGT 1080
Leu Asn Phe Thr Ala Asp Val Gln Ser Gly Met Gly
350 355 360

GCT ACA GTA TTT TCA CTG AAT ACA A[illegible]A GGT GGT GTC 1116
Ala Thr Val Phe Ser Leu Asn Thr Thr Gly Gly Val
365 370

ATT CTT GAA ATT TCA TGT TAT AGT GAC ACA GTG AGT 1152
Ile Leu Glu Ile Ser Cys Tyr Ser Asp Thr Val Ser
375 380

GAG TCT AGT TCT TAC AGT TAT GGT GAA ATC CCG TTC 1188
Glu Ser Ser Ser Tyr Ser Tyr Gly Glu Ile Pro Phe
385 390 395

GGC ATA ACT GAC GGA CCA CGA TAC TGT TAT GTA CTT 1224
Gly Ile Thr Asp Gly Pro Arg Tyr Cys Tyr Val Leu
400 405

TAC AAT GGC ACA GCT CTT AAA TAT TTA GGA ACA TTA 1260
Tyr Asn Gly Thr Ala Leu Lys Tyr Leu Gly Thr Leu
410 415 420

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FIGURE 2 (cont'd)

```
CCA CCC AGT GTA AAG GAA ATT GCT ATT AGT AAG TGG     1296
Pro Pro Ser Val Lys Glu Ile Ala Ile Ser Lys Trp
                425                 430

GGC CAT TTT TAT ATT AAT GGT TAC AAT TTC TTT AGC     1332
Gly His Phe Tyr Ile Asn Gly Tyr Asn Phe Phe Ser
        435                 440

ACA TTT CCT ATT GAT TGT ATA TCT TTT AAT TTA ACC     1368
Thr Phe Pro Ile Asp Cys Ile Ser Phe Asn Leu Thr
445                 450                 455

ACT GGT GTT AGT GGA GCT TTT TGG ACA ATT GCT TAC     1404
Thr Gly Val Ser Gly Ala Phe Trp Thr Ile Ala Tyr
            460                 465

ACA TCG TAT ACT GAA GCA TTA GTA CAA GTT GAA AAC     1440
Thr Ser Tyr Thr Glu Ala Leu Val Gln Val Glu Asn
    470                 475                 480

ACA GCT ATT AAA AAT GTG ACG TAT TGT AAC AGT CAC     1476
Thr Ala Ile Lys Asn Val Thr Tyr Cys Asn Ser His
                485                 490

ATT AAT AAC ATT AAA TGT TCT CAA CTT ACT GCT AAT     1512
Ile Asn Asn Ile Lys Cys Ser Gln Leu Thr Ala Asn
        495                 500

TTG AAT AAT GGA TTT TAT CCT GTT GCT TCA AGT GAA     1548
Leu Asn Asn Gly Phe Tyr Pro Val Ala Ser Ser Glu
505                 510                 515

GTA GGT TTC GTT AAT AAG AGT GTT GTG TTA TTA CCT     1584
Val Gly Phe Val Asn Lys Ser Val Val Leu Leu Pro
            520                 525

AGC TTT TTC ACA TAC ACC GCT GTC AAT ATA ACC ATT     1620
Ser Phe Phe Thr Tyr Thr Ala Val Asn Ile Thr Ile
    530                 535                 540

GAT CTT GGT ATG AAG CTT AGT GGT TAT GGT CAA CCC     1656
Asp Leu Gly Met Lys Leu Ser Gly Tyr Gly Gln Pro
                545                 550

ATA GCC TCG ACA CTA AGT AAC ATC ACA CTA CCA ATG     1692
Ile Ala Ser Thr Leu Ser Asn Ile Thr Leu Pro Met
        555                 560

CAG GAT AAC AAT ACT GAT GTG TAC TGT ATT CGT TCT     1728
Gln Asp Asn Asn Thr Asp Val Tyr Cys Ile Arg Ser
565                 570                 575
```

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FIGURE 2 (cont'd)

```
AAC CAA TTC TCA GTT TAT GTT CAT TCC ACT TGC AAA    1764
Asn Gln Phe Ser Val Tyr Val His Ser Thr Cys Lys
            580                 585

AGT TCT TTA TGG GAC AAT ATT TTT AAT CAA GAC TGC    1800
Ser Ser Leu Trp Asp Asn Ile Phe Asn Gln Asp Cys
    590                 595                 600

ACG GAT GTT TTA GAG GCT ACA GCT GTT ATA AAA ACT    1836
Thr Asp Val Leu Glu Ala Thr Ala Val Ile Lys Thr
                605                 610

GGT ACT TGT CCT TTC TCA TTT GAT AAA TTG AAC AAT    1872
Gly Thr Cys Pro Phe Ser Phe Asp Lys Leu Asn Asn
        615                 620

                    A*
TAC TTG ACT TTT AAC ACG TTC TGT TTG TCG TTG AGT    1908
Tyr Leu Thr Phe Asn Thr Phe Cys Leu Ser Leu Ser
625                 Lys*                635
                    630

CCT GTT GGT GCT AAT TGC AAG TTT GAT GTT GCT GCA    1944
Pro Val Gly Ala Asn Cys Lys Phe Asp Val Ala Ala
            640                 645

CGT ACA AGA ACC AAT GAG CAG GTT GTT AGA AGT CTA    1980
Arg Thr Arg Thr Asn Glu Gln Val Val Arg Ser Leu
    650                 655                 660

    G*
TAT ATA ATA TAT GAA GAA GGA GAC AAC ATA GTG GGT    2016
Tyr Ile Ile Tyr Glu Glu Gly Asp Asn Ile Val Gly
    Val*        665                 670

GTA CCG TCT GAT GAT AGC GGT CTG CAC GAT TTG TCT    2052
Val Pro Ser Asp Asp Ser Gly Leu His Asp Leu Ser
        675                 680

GTG CTA CAC CTA GAC TCC TGT ACA GAT TAC AAT ATA    2088
Val Leu His Leu Asp Ser Cys Thr Asp Tyr Asn Ile
685                 690                 695

TAT GGT AGA ACT GGT GTT GGT ATT ATT AGA CGA ACT    2124
Tyr Gly Arg Thr Gly Val Gly Ile Ile Arg Arg Thr
            700                 705

AAC AGT ACG CTA CTT AGT GGC TTA TAT TAC ACA TCA    2160
Asn Ser Thr Leu Leu Ser Gly Leu Tyr Tyr Thr Ser
    710                 715                 720
```

FIGURE 2 (cont'd)

```
CTA TCA GGT GAT TTG TTA GGC TTT AAA AAT GTT AGT    2196
Leu Ser Gly Asp Leu Leu Gly Phe Lys Asn Val Ser
                725                 730

GAT GGT GTC ATT TAT TCT GTG ACG CCA TGT GAT GTA    2232
Asp Gly Val Ile Tyr Ser Val Thr Pro Cys Asp Val
        735                 740

AGC GCA CAA GCG GCT GTT ATT GAT GGT GCC ATA GTT    2268
Ser Ala Gln Ala Ala Val Ile Asp Gly Ala Ile Val
745                 750                 755

GGA GCT ATG ACT TCC ATT AAC AGT GAA CTG TTA GGT    2304
Gly Ala Met Thr Ser Ile Asn Ser Glu Leu Leu Gly
            760                 765

CTA ATA CAT TGG ACA ACG ACA CCT AAT TTT TAT TAC    2340
Leu Ile His Trp Thr Thr Thr Pro Asn Phe Tyr Tyr
    770                 775                 780

TAC TCT ATA TAT AAT TAC ACA AGT GAG AGG ACT CGT    2376
Tyr Ser Ile Tyr Asn Tyr Thr Ser Glu Arg Thr Arg
                785                 790

GGC ACT GCA ATT GAC AGT AAC GAT GTT GAT TGT GAA    2412
Gly Thr Ala Ile Asp Ser Asn Asp Val Asp Cys Glu
        795                 800

CCT GTC ATA ACC TAT TCT AAT ATA GGT GTT TGT AAA    2448
Pro Val Ile Thr Tyr Ser Asn Ile Gly Val Cys Lys
805                 810                 815

AAT GGT GCT TTG GTT TTT ATT AAC GTC ACA CAT TCT    2484
Asn Gly Ala Leu Val Phe Ile Asn Val Thr His Ser
            820                 825

GAC GGA GAC GTG CAA CCA ATT AGC ACT GGT AAT GTC    2520
Asp Gly Asp Val Gln Pro Ile Ser Thr Gly Asn Val
    830                 835                 840

ACG ATA CCT ACA AAT TTT ACC ATA TCT GTG CAA GTT    2556
Thr Ile Pro Thr Asn Phe Thr Ile Ser Val Gln Val
                845                 850

GAA TAC ATG CAG GTT TAC ACT ACA CCA GTA TCA ATA    2592
Glu Tyr Met Gln Val Tyr Thr Thr Pro Val Ser Ile
        855                 860

GAT TGT GCA AGA TAC GTT TGT AAT GGT AAC CCT AGA    2628
Asp Cys Ala Arg Tyr Val Cys Asn Gly Asn Pro Arg
865                 870                 875
```

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FIGURE 2 (cont'd)

```
TGT AAC AAA TTG TTA ACA CAA TAT GTG TCT GCA TGT    2664
Cys Asn Lys Leu Leu Thr Gln Tyr Val Ser Ala Cys
            880                 885

CAA ACT ATT GAA CAA GCA CTT GCA ATG GGT GCC AGA    2700
Gln Thr Ile Glu Gln Ala Leu Ala Met Gly Ala Arg
    890                 895                 900

CTT GAA AAC ATG GAG GTT GAT TCC ATG TTG TTT GTC    2736
Leu Glu Asn Met Glu Val Asp Ser Met Leu Phe Val
                905                 910

TCG GAA AAT GCC CTT AAA TTG GCA TCT GTT GAG GCG    2772
Ser Glu Asn Ala Leu Lys Leu Ala Ser Val Glu Ala
        915                 920

TTC AAT AGT ACA GAA AAT TTA GAT CCT ATT TAC AAA    2808
Phe Asn Ser Thr Glu Asn Leu Asp Pro Ile Tyr Lys
925                 930                 935

GAA TGG CCT AGC ATA GGT GGT TCT TGG CTA GGA GGT    2844
Glu Trp Pro Ser Ile Gly Gly Ser Trp Leu Gly Gly
            940                 945

CTA AAA GAT ATA CTA CCG TCC CAT AAT AGC AAA CGT    2880
Leu Lys Asp Ile Leu Pro Ser His Asn Ser Lys Arg
    950                 955                 960

AAG TAT GGT TCT GCT ATA GAA GAT TTG CTT TTT GAT    2916
Lys Tyr Gly Ser Ala Ile Glu Asp Leu Leu Phe Asp
                965                 970

AAA GTT GTA ACA TCT GGT TTA GGT ACA GTT GAT GAA    2952
Lys Val Val Thr Ser Gly Leu Gly Thr Val Asp Glu
        975                 980

GAT TAT AAA CGT TGT ACT GGT GGT TAC GAC ATA GCA    2988
Asp Tyr Lys Arg Cys Thr Gly Gly Tyr Asp Ile Ala
985                 990                 995

GAC TTG GTG TGT GCT CAA TAT TAC AAT GGC ATC ATG    3024
Asp Leu Val Cys Ala Gln Tyr Tyr Asn Gly Ile Met
            1000                1005

GTT CTA CCA GGT GTA GCT AAT GCT GAC AAG ATG ACT    3060
Val Leu Pro Gly Val Ala Asn Ala Asp Lys Met Thr
    1010                1015                1020

ATG TAC ACA GCA TCA CTT GCA GGT GGT ATA ACA TTA    3096
Met Tyr Thr Ala Ser Leu Ala Gly Gly Ile Thr Leu
                1025                1030
```

FIGURE 2 (cont'd)

GGT GCA CTT GGT GGT GGC GCC GTG GCT ATA CCT TTT 3132
Gly Ala Leu Gly Gly Gly Ala Val Ala Ile Pro Phe
1035 1040

GCA GTA GCA GTA CAG GCT AGA CTT AAT TAT GTT GCT 3168
Ala Val Ala Val Gln Ala Arg Leu Asn Tyr Val Ala
1045 1050 1055

CTA CAA ACT GAT GTA TTG AAT AAA AAC CAA CAG ATC 3204
Leu Gln Thr Asp Val Leu Asn Lys Asn Gln Gln Ile
1060 1065

CTG GCT AAT GCT TTC AAT CAA GCT ATT GGT AAC ATT 3240
Leu Ala Asn Ala Phe Asn Gln Ala Ile Gly Asn Ile
1070 1075 1080

ACA CAG GCT TTT GGT AAG GTT AAT GAT GCT ATA CAT 3276
Thr Gln Ala Phe Gly Lys Val Asn Asp Ala Ile His
1085 1090

CAA ACA TCA CAA GGT CTT GCC ACT GTT GCT AAA GCG 3312
Gln Thr Ser Gln Gly Leu Ala Thr Val Ala Lys Ala
1095 1100

TTG GCA AAA GTG CAA GAT GTT GTC AAC ACA CAA GGG 3348
Leu Ala Lys Val Gln Asp Val Val Asn Thr Gln Gly
1105 1110 1115

CAA GCT TTA AGT CAC CTT ACA GTA CAA TTG CAA AAT 3384
Gln Ala Leu Ser His Leu Thr Val Gln Leu Gln Asn
1120 1125

AAT TTT CAA GCC ATT AGT AGT TCT ATT AGT GAT ATT 3420
Asn Phe Gln Ala Ile Ser Ser Ser Ile Ser Asp Ile
1130 1135 1140

TAT AAC AGG CTT GAC GAA CTG AGT GCT GAT GCA CAA 3456
Tyr Asn Arg Leu Asp Glu Leu Ser Ala Asp Ala Gln
1145 1150

GTT GAT AGG CTG ATT ACA GGT AGA CTT ACA GCA CTT 3492
Val Asp Arg Leu Ile Thr Gly Arg Leu Thr Ala Leu
1155 1160

AAT GCA TTT GTG TCT CAG ACT CTA ACC AGA CAA GCA 3528
Asn Ala Phe Val Ser Gln Thr Leu Thr Arg Gln Ala
1165 1170 1175

GAG GTT AGG GCT AGT AGA CAA CTT GCC AAA GAC AAG 3564
Glu Val Arg Ala Ser Arg Gln Leu Ala Lys Asp Lys
1180 1185

FIGURE 2 (cont'd)

```
GTT AAT GAA TGT GTT AGG TCT CAG TCT CAG AGA TTC    3600
Val Asn Glu Cys Val Arg Ser Gln Ser Gln Arg Phe
    1190                1195                1200

GGA TTC TGT GGT AAT GGT ACA CAT TTG TTT TCA CTA    3636
Gly Phe Cys Gly Asn Gly Thr His Leu Phe Ser Leu
            1205                1210

GCA AAT GCA GCA CCA AAT GGC ATG ATT TTC TTT CAT    3672
Ala Asn Ala Ala Pro Asn Gly Met Ile Phe Phe His
        1215                1220

ACA GTA CTA TTA CCA ACA GCT TAT GAA ACT GTA ACA    3708
Thr Val Leu Leu Pro Thr Ala Tyr Glu Thr Val Thr
1225                1230                1235

GCT TGG TCA GGT ATT TGT GCT TCA GAT GGC GAT CGC    3744
Ala Trp Ser Gly Ile Cys Ala Ser Asp Gly Asp Arg
            1240                1245

ACT TTC GGA CTT GTC GTT AAA GAT GTG CAG TTG ACG    3780
Thr Phe Gly Leu Val Val Lys Asp Val Gln Leu Thr
    1250                1255                1260

TTG TTT CGT AAT CTA GAT GAC AAG TTC TAT TTG ACC    3816
Leu Phe Arg Asn Leu Asp Asp Lys Phe Tyr Leu Thr
            1265                1270

CCC AGA ACT ATG TAT CAG CCT AGA GTT GCA ACT AGT    3852
Pro Arg Thr Met Tyr Gln Pro Arg Val Ala Thr Ser
        1275                1280

TCT GAT TTT GTT CAA ATT GAA GGG TGT GAT GTG TTG    3888
Ser Asp Phe Val Gln Ile Glu Gly Cys Asp Val Leu
1285                1290                1295

TTT GTC AAC GCG ACT GTA ATT GAT TTG CCT AGT ATT    3924
Phe Val Asn Ala Thr Val Ile Asp Leu Pro Ser Ile
            1300                1305

ATA CCT GAC TAT ATT GAC ATT AAT CAA ACT GTT CAA    3960
Ile Pro Asp Tyr Ile Asp Ile Asn Gln Thr Val Gln
    1310                1315                1320

GAC ATA TTA GAA AAT TAC AGA CCA AAC TGG ACT GTA    3996
Asp Ile Leu Glu Asn Tyr Arg Pro Asn Trp Thr Val
            1325                1330

CCT GAA TTT ACA CTT GAT ATT TTC AAC ACA ACC TAT    4032
Pro Glu Phe Thr Leu Asp Ile Phe Asn Thr Thr Tyr
        1335                1340
```

FIGURE 2 (cont'd)

TTA AAT CTG ACT GGT GAA ATT GAT GAC TTA GAG TTT 4068
Leu Asn Leu Thr Gly Glu Ile Asp Asp Leu Glu Phe
1345 1350 1355

AGG TCG GAA AAG CTA CAT AAC ACT ACA GTA GAA CTT 4104
Arg Ser Glu Lys Leu His Asn Thr Thr Val Glu Leu
1360 1365

GCC ATT CTC ATT GAT AAC ATT AAT AAT ACA TTA GTC 4140
Ala Ile Leu Ile Asp Asn Ile Asn Asn Thr Leu Val
1370 1375 1380

AAT CTT GAA TGG CTC AAT AGA ATT GAA ACT TAT GTA 4176
Asn Leu Glu Trp Leu Asn Arg Ile Glu Thr Tyr Val
1385 1390

AAA TGG CCT TGG TAT GTG TGG CTA CTG ATA GGT TTA 4212
Lys Trp Pro Trp Tyr Val Trp Leu Leu Ile Gly Leu
1395 1400

GTA GTA GTA TTT TGC ATA CCA TTA CTG CTA TTT TGC 4248
Val Val Val Phe Cys Ile Pro Leu Leu Leu Phe Cys
1405 1410 1415

TGT TTT AGC ACA GGT TGT TGT GGA TGC ATA GGT TGT 4284
Cys Phe Ser Thr Gly Cys Cys Gly Cys Ile Gly Cys
1420 1425

TTA GGA AGT TGT TGT CAC TCT ATA TGT AGT AGA AGA 4320
Leu Gly Ser Cys Cys His Ser Ile Cys Ser Arg Arg
1430 1435 1440

CAA TTT GAA AAT TAT GAA CCA ATT GAA AAA GTG CAT 4356
Gln Phe Glu Asn Tyr Glu Pro Ile Glu Lys Val His
1445 1450

GTC CAC TAA 4365
Val His

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FIGURE 3

TN406, nucleotides 302 - 671 [SEQ ID NO:]
TN406, amino acids 102 - 223 [SEQ ID NO:]

```
GT GGT AAA CCA TTA TTA TTT CAT GTG CAT GGT GAG CCT     339
   Gly Lys Pro Leu Leu Phe His Val His Gly Glu Pro
   102             106                 111

GTT AGT GTT ATT ATA TAT ATA TCG GCT TAT AGG GAT GAT    378
Val Ser Val Ile Ile Tyr Ile Ser Ala Tyr Arg Asp Asp
        116                 121                 126

GTG CAA CAA AGG CCC CTT TTA AAA CAT GGG TTA GTG TGC    417
Val Gln Gln Arg Pro Leu Leu Lys His Gly Leu Val Cys
                131                 136

ATA ACT AAA AAT CGC CAT ATT AAC TAT GAA CAA TTC ACC    456
Ile Thr Lys Asn Arg His Ile Asn Tyr Glu Gln Phe Thr
    141                 146                 151

TCC AAC CAG TGG AAT TCC ACA TGT ACG GGT GCT GAC AGA    495
Ser Asn Gln Trp Asn Ser Thr Cys Thr Gly Ala Asp Arg
            156                 161

AAA ATT CCT TTC TCT GTC ATA CCC ACG GAC AAT GGA ACA    534
Lys Ile Pro Phe Ser Val Ile Pro Thr Asp Asn Gly Thr
166                 171                 176

AAA ATC TAT GGT CTT GAG TGG AAT GAT GAC TTT GTT ACA    573
Lys Ile Tyr Gly Leu Glu Trp Asn Asp Asp Phe Val Thr
    181                 186                 191

GCT TAT ATT AGT GGT CGT TCT TAT CAC TTG AAC ATC AAT    612
Ala Tyr Ile Ser Gly Arg Ser Tyr His Leu Asn Ile Asn
            196                 201

ACT AAT TGG TTT AAC AAT GTC ACA CTT TTG TAT TCA CGC    651
Thr Asn Trp Phe Asn Asn Val Thr Leu Leu Tyr Ser Arg
206                 211                 216

TCA AGC ATT GCT ACC TGG GA                             671
Ser Ser Ile Ala Thr Trp
        221
```

FIGURE 4

FECV, nucleotides 1 - 4365 [SEQ ID NO:]
FECV, amino acids 1 - 1454 [SEQ ID NO:]

ATG ATT GTG CTC GTA ACT TGC CTC TTG TTG TTA TGC 36
Met Ile Val Leu Val Thr Cys Leu Leu Leu Leu Cys
1 5 10

TCA TAC CAC ACT GTT TCG AGT ACG TCA AAC AAT GAT 72
Ser Tyr His Thr Val Ser Ser Thr Ser Asn Asn Asp
15 20

TGT AGA CAA GTT AAC GTA ACA CAA TTA GCT GGC AAT 108
Cys Arg Gln Val Asn Val Thr Gln Leu Ala Gly Asn
25 30 35

GAA AAC CTT ATT AGA GAC TTT TTG TTT CAA AGT TTT 144
Glu Asn Leu Ile Arg Asp Phe Leu Phe Gln Ser Phe
40 45

AAA GAA GAA GGA ATT GTA GTT GTT GGT GGT TAT TAC 180
Lys Glu Glu Gly Ile Val Val Val Gly Gly Tyr Tyr
50 55 60

CCT ACA GAG GTG TGG TAC AAC TGC TCT AGA ACA GCA 216
Pro Thr Glu Val Trp Tyr Asn Cys Ser Arg Thr Ala
65 70

ACT ACC ACT GCC TAT GAG TAT TTT AAT AAT ATA CAT 252
Thr Thr Thr Ala Tyr Glu Tyr Phe Asn Asn Ile His
75 80

GCC TTT TAT TTT GAT ATG GAA GCT ATG GAA AAT AGC 288
Ala Phe Tyr Phe Asp Met Glu Ala Met Glu Asn Ser
85 90 95

ACT GGT AAT GCA CGT GGT AAA CCT CTA TTA TTT CAT 324
Thr Gly Asn Ala Arg Gly Lys Pro Leu Leu Phe His
↑ 100 105
97 of WSU 1146
amino acid #62 of AR58-3

GTT CAT GGT GAA CCT GTT AGT ATC ATC ATA TAT ATA 360
Val His Gly Glu Pro Val Ser Ile Ile Ile Tyr Ile
110 115 120

TCA GCT TAT GGG GAT GAT GTG CAA CAA AGG CCA CTT 396
Ser Ala Tyr Gly Asp Asp Val Gln Gln Arg Pro Leu
125 130

FIGURE 4 (cont'd)

```
TTA GAA CAT GGG TTA TTG TGC ATT ACT AAA AAT CGC     432
Leu Glu His Gly Leu Leu Cys Ile Thr Lys Asn Arg
        135                 140

AAT ATT GAC TAT AAC ACC TTC ACC AGC AAC CAG TGG     468
Asn Ile Asp Tyr Asn Thr Phe Thr Ser Asn Gln Trp
145                 150                 155

GAT TCC ATA TGT ACG GGT AAT GAC AGA AAA ATT CCT     504
Asp Ser Ile Cys Thr Gly Asn Asp Arg Lys Ile Pro
            160                 165

TTC TCT GTC ATA CCC AGG GAT AAT GGA ACA AAA ATC     540
Phe Ser Val Ile Pro Arg Asp Asn Gly Thr Lys Ile
    170                 175                 180

TAT CGG CTT GAG TGG AAT GAT GAA TTT GTT ACA GCG     576
Tyr Gly Leu Glu Trp Asn Asp Glu Phe Val Thr Ala
                185                 190

TAT ATT AGT GGT CGT TCT TAT AAT TGG AAC ATC AAT     612
Tyr Ile Ser Gly Arg Ser Tyr Asn Trp Asn Ile Asn
        195                 200

AAT AAC TGG TTT AAC AAT GTC ACA CTT TTG TAT TCA     648
Asn Asn Trp Phe Asn Asn Val Thr Leu Leu Tyr Ser
205                 210                 215

CGC TCA AGC ACT GCT ACC TGG GAA TAC AGT GCT GCA     684
Arg Ser Ser Thr Ala Thr Trp Glu Tyr Ser Ala Ala
            220                 225

TAT GTT TAC CAA GGT GTT TCT AAC TTC ACT TAT TAC     720
Tyr Val Tyr Gln Gly Val Ser Asn Phe Thr Tyr Tyr
    230                 235                 240

AAG TTA AAT AAC ACC AAT GGT TTA AAA ACC TAT GAA     756
Lys Leu Asn Asn Thr Asn Gly Leu Lys Thr Tyr Glu
                245                 250

TTT TGT GAG GAT TAT GAA TAT TGC ACT GGC TAC GCC     792
Phe Cys Glu Asp Tyr Glu Tyr Cys Thr Gly Tyr Ala
        255                 260

ACT AAT GTC TTT GCT CCA ACT GTG GGA GGT TAC ATA     828
Thr Asn Val Phe Ala Pro Thr Val Gly Gly Tyr Ile
265                 270                 275

CCT GAT GGA TTT AGT TTT AAC AAT TGG TTT TTG CTT     864
Pro Asp Gly Phe Ser Phe Asn Asn Trp Phe Leu Leu
            280                 285
```

FIGURE 4 (cont'd)

```
ACA AAT AGC TCC ACT TTT GTT AGT GGC AGA TTT GTA     900
Thr Asn Ser Ser Thr Phe Val Ser Gly Arg Phe Val
    290                 295                 300

ACA AAC CAA CCA CTA TTA GTT AAC TGC TTA TGG CCA     936
Thr Asn Gln Pro Leu Leu Val Asn Cys Leu Trp Pro
                305                 310

GTG CCC AGT TTT GGT GTA GCA GCA CAA GAA TTT TGT     972
Val Pro Ser Phe Gly Val Ala Ala Gln Glu Phe Cys
        315                 320

TTT GAA GGT GCG CAG TTT AGT CAG TGT AGT GGT GTA    1008
Phe Glu Gly Ala Gln Phe Ser Gln Cys Ser Gly Val
325                 330                 335

TCT TTA AAT AAC ACA GTA GAT GTT ATT AGA TTC AAT    1044
Ser Leu Asn Asn Thr Val Asp Val Ile Arg Phe Asn
            340                 345

CTT AAT TTC ACC GCA GAT GTA CAA TCT GGT ATG GGT    1080
Leu Asn Phe Thr Ala Asp Val Gln Ser Gly Met Gly
    350                 355                 360

GCT ACA GTG TTT TCG TTG AAT ACA ACG GGT GGT GTC    1116
Ala Thr Val Phe Ser Leu Asn Thr Thr Gly Gly Val
                365                 370

ATT CTT GAA GTT TCA TGT TAT AAT GAC ACA GTG AGT    1152
Ile Leu Glu Val Ser Cys Tyr Asn Asp Thr Val Ser
        375                 380

GAG TCT AGT TTT TAC AGT TAT GGT GAA ATT CCG TTC    1188
Glu Ser Ser Phe Tyr Ser Tyr Gly Glu Ile Pro Phe
385                 390                 395

GGC ATA ACT GAT GGA CCA CGG TAC TGT TAT GTA CTT    1224
Gly Ile Thr Asp Gly Pro Arg Tyr Cys Tyr Val Leu
            400                 405

TAC AAT GGC ACA GCT CTT AAG TAT TTA GGA ACA TTA    1260
Tyr Asn Gly Thr Ala Leu Lys Tyr Leu Gly Thr Leu
    410                 415                 420

CCA CCT AGT GTA AAG GAA ATT GCT ATT AGT AAG TGG    1296
Pro Pro Ser Val Lys Glu Ile Ala Ile Ser Lys Trp
                425                 430

GGC CAT TTT TAT ATT AAT GGT TAC AAT TTC TTT AGC    1332
Gly His Phe Tyr Ile Asn Gly Tyr Asn Phe Phe Ser
        435                 440
```

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FIGURE 4 (cont'd)

```
ACA TTT CCT ATT GAT TGT ATA TCT TTT AAC TTA ACC    1368
Thr Phe Pro Ile Asp Cys Ile Ser Phe Asn Leu Thr
445                 450                 455

ACT GGT GAT AGT GGA GCT TTT TGG ACA ATT GCT TAC    1404
Thr Gly Asp Ser Gly Ala Phe Trp Thr Ile Ala Tyr
            460                 465

ACA TCG TAC ACT GAG GCA TTA GTA CAA GTT GAA AAC    1440
Thr Ser Tyr Thr Glu Ala Leu Val Gln Val Glu Asn
    470                 475                 480

ACA GCT ATT AAA AAG GTG ACG TAT TGT AAC AGT CAC    1476
Thr Ala Ile Lys Lys Val Thr Tyr Cys Asn Ser His
                485                 490

ATT AAT AAC ATT AAG TGT TCT CAA CTT ACT GCT AAT    1512
Ile Asn Asn Ile Lys Cys Ser Gln Leu Thr Ala Asn
        495                 500

TTG AAT AAT GGA TTT TAT CCT GTT GCT TCA AGT GAG    1548
Leu Asn Asn Gly Phe Tyr Pro Val Ala Ser Ser Glu
505                 510                 515

GTT GGT CTT GTG AAT AAG AGT GTT GTG TTA TTA CCT    1584
Val Gly Leu Val Asn Lys Ser Val Val Leu Leu Pro
            520                 525

ATC TTT TTC GCA CAT ACC GCT ATC AAT ATA ACC ATT    1620
Ile Phe Phe Ala His Thr Ala Ile Asn Ile Thr Ile
    530                 535                 540

GAT CTT GGT ATG AAG CGT AGC GGT TAT GGT CAA CCC    1656
Asp Leu Gly Met Lys Arg Ser Gly Tyr Gly Gln Pro
                545                 550

ATA GCA TCA ACA TTA AGT AAC ATT ACA CTA CCA ATG    1692
Ile Ala Ser Thr Leu Ser Asn Ile Thr Leu Pro Met
        555                 560

CAG GAT AAT AAC ACA GAT GTG TAC TGT ATT CGT TCT    1728
Gln Asp Asn Asn Thr Asp Val Tyr Cys Ile Arg Ser
565                 570                 575

AAC CAG TTT TCA GTT TAT GTT CAT TCT ATT TGT AAG    1764
Asn Gln Phe Ser Val Tyr Val His Ser Ile Cys Lys
            580                 585

AGT TCT TTA TGG GAC AAT ATT TTT AAT CAA GAA TGC    1800
Ser Ser Leu Trp Asp Asn Ile Phe Asn Gln Glu Cys
    590                 595                 600
```

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FIGURE 4 (cont'd)

```
ACG GAT GTT TTA GAT GCC ACA GCT GTT ATA AAG ACT     1836
Thr Asp Val Leu Asp Ala Thr Ala Val Ile Lys Thr
                605                 610

GGT ACT TGT CCT TTC TCA TTT GAT AAA TTG AAC AAT     1872
Gly Thr Cys Pro Phe Ser Phe Asp Lys Leu Asn Asn
        615                 620

TAC TTA ACT TTT AAC AAG TTC TGT TTG TCG TTG AGT     1908
Tyr Leu Thr Phe Asn Lys Phe Cys Leu Ser Leu Ser
625                 630                 635

CCT GTT GGC GCT AAC TGC AAG TTT GAT GTT GCC GCA     1944
Pro Val Gly Ala Asn Cys Lys Phe Asp Val Ala Ala
            640                 645

CGT ACA AGA ACC AAT GAG CAA GTT GTT AGA AGT CTA     1980
Arg Thr Arg Thr Asn Glu Gln Val Val Arg Ser Leu
    650                 655                 660

TAT GTA ATA TAT GAA GAA GGA GAC AAC ATA GTT GGT     2016
Tyr Val Ile Tyr Glu Glu Gly Asp Asn Ile Val Gly
                665                 670

GTA CCG TCT GAT AAT AGC GGT CTG CAC GAT TTG TCT     2052
Val Pro Ser Asp Asn Ser Gly Leu His Asp Leu Ser
        675                 680

GTG CTA CAC CTA GAC TCC TGT ACA GAG TAT AAT ATA     2088
Val Leu His Leu Asp Ser Cys Thr Glu Tyr Asn Ile
685                 690                 695

TAT GGT AGA ACT GGT GTT GGT ATT ATT AGA CAA ACT     2124
Tyr Gly Arg Thr Gly Val Gly Ile Ile Arg Gln Thr
            700                 705

AAC AGT ACG CTA CTT AGC GGC TTA TAT TAC ACA TCA     2160
Asn Ser Thr Leu Leu Ser Gly Leu Tyr Tyr Thr Ser
    710                 715                 720

CTA TCA GGT GAT TTG TTA GGC TTT AAA AAT GTT AGT     2196
Leu Ser Gly Asp Leu Leu Gly Phe Lys Asn Val Ser
                725                 730

GAT GGT GTC ATC TAT TCT GTG ACG CCA TGT GAT GTA     2232
Asp Gly Val Ile Tyr Ser Val Thr Pro Cys Asp Val
        735                 740

AGC GCA CAA GCG GCT GTT ATT GAT GGT GCC ATA GTT     2268
Ser Ala Gln Ala Ala Val Ile Asp Gly Ala Ile Val
745                 750                 755
```

FIGURE 4 (cont'd)

```
GGA GCT ATG ACT TCC ATT AAC AGT GAA CTG TTA GGT     2304
Gly Ala Met Thr Ser Ile Asn Ser Glu Leu Leu Gly
            760                 765

CTA AAA CAC TGG ACA ACA ACA CCT AAT TTT TAT TAC     2340
Leu Lys His Trp Thr Thr Thr Pro Asn Phe Tyr Tyr
    770                 775                 780

TAC TCT ATA TAT AAT TAT ACA AAT GAG AGG ACT CGT     2376
Tyr Ser Ile Tyr Asn Tyr Thr Asn Glu Arg Thr Arg
                785                 790

GGC ACT GCA ATT GAC AGT AAC GAT GTT GAT TGT GAA     2412
Gly Thr Ala Ile Asp Ser Asn Asp Val Asp Cys Glu
        795                 800

CCT ATC ATA ACC TAT TCT AAC ATA GGT GTT TGT AAA     2448
Pro Ile Ile Thr Tyr Ser Asn Ile Gly Val Cys Lys
805                 810                 815

AAT GGT GCT TTG GTT TTT ATT AAC GTC ACA CAT TCT     2484
Asn Gly Ala Leu Val Phe Ile Asn Val Thr His Ser
            820                 825

GAT GGA GAC GTG CAA CCA ATT AGC ACT GGT ACT GTC     2520
Asp Gly Asp Val Gln Pro Ile Ser Thr Gly Thr Val
    830                 835                 840

ACG ATA CCT ACA AAC TTT ACC ATA TCT GTG CAA GTC     2556
Thr Ile Pro Thr Asn Phe Thr Ile Ser Val Gln Val
                845                 850

GAA TAC ATT CAG GTT TAC ACC ACA CCA GTA TCA ATA     2592
Glu Tyr Ile Gln Val Tyr Thr Thr Pro Val Ser Ile
        855                 860

GAT TGT GCA AGA TAC GTT TGC AAT GGT AAC CCT AGA     2628
Asp Cys Ala Arg Tyr Val Cys Asn Gly Asn Pro Arg
865                 870                 875

TGT AAC AAA TTG TTA ACA CAA TAT GTT TCT GCA TGT     2664
Cys Asn Lys Leu Leu Thr Gln Tyr Val Ser Ala Cys
            880                 885

CAA ACT ATT GAG CAA GCA CTT GCA ATG GGT GCC AGA     2700
Gln Thr Ile Glu Gln Ala Leu Ala Met Gly Ala Arg
    890                 895                 900

CTT GAA AAC ATG GAG GTT GAT TCC ATG TTG TTC GTT     2736
Leu Glu Asn Met Glu Val Asp Ser Met Leu Phe Val
                905                 910
```

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FIGURE 4 (cont'd)

```
TCT GAA AAT GCC CTT AAA TTG GCA TCT GTT GAG GCG    2772
Ser Glu Asn Ala Leu Lys Leu Ala Ser Val Glu Ala
        915                 920

TTC AAT AGT ACA GAA AAT TTA GAC CCT ATT TAC AAA    2808
Phe Asn Ser Thr Glu Asn Leu Asp Pro Ile Tyr Lys
925                 930                 935

GAA TGG CCT AAC ATA GGT GGT TCT TGG TTA GGA GGT    2844
Glu Trp Pro Asn Ile Gly Gly Ser Trp Leu Gly Gly
            940                 945

TTA AAA GAC ATA CTG CCG TCC CAT AAT AGC AAA CGT    2880
Leu Lys Asp Ile Leu Pro Ser His Asn Ser Lys Arg
    950                 955                 960

AAG TAT CGT TCT GCT ATA GAA GAC TTG CTT TTT GAT    2916
Lys Tyr Arg Ser Ala Ile Glu Asp Leu Leu Phe Asp
                965                 970

AAG GTT GTA ACT TCT GGT TTA GGT ACA GTT GAT GAA    2952
Lys Val Val Thr Ser Gly Leu Gly Thr Val Asp Glu
        975                 980

GAT TAT AAA CGT TGT ACA GGT GGT TAT GAC ATA GCC    2988
Asp Tyr Lys Arg Cys Thr Gly Gly Tyr Asp Ile Ala
985                 990                 995

GAC TTA GTG TGT GCT CAA TAT TAC AAT GGC ATC ATG    3024
Asp Leu Val Cys Ala Gln Tyr Tyr Asn Gly Ile Met
            1000                1005

GTG TTA CCT GGT GTA GCT AAT GAT GAC AAG ATG ACT    3060
Val Leu Pro Gly Val Ala Asn Asp Asp Lys Met Thr
    1010                1015                1020

ATG TAC ACA GCA TCT CTT GCA GGT GGT ATA ACA CTA    3096
Met Tyr Thr Ala Ser Leu Ala Gly Gly Ile Thr Leu
                1025                1030

GGT GCA CTT GGT GGT GGC GCC GTT GCT ATA CCT TTT    3132
Gly Ala Leu Gly Gly Gly Ala Val Ala Ile Pro Phe
        1035                1040

GCA GTA GCA GTT CAA GCT AGA CTT AAT TAT GTT GCT    3168
Ala Val Ala Val Gln Ala Arg Leu Asn Tyr Val Ala
1045                1050                1055

CTA CAA ACT GAT GTA TTG AAT AAA AAC CAG CAG ATC    3204
Leu Gln Thr Asp Val Leu Asn Lys Asn Gln Gln Ile
            1060                1065
```

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FIGURE 4 (cont'd)

```
CTG GCT AAT GCT TTC AAT CAA GCT ATT GGT AAC ATT    3240
Leu Ala Asn Ala Phe Asn Gln Ala Ile Gly Asn Ile
    1070                1075                1080

ACA CAG GCA TTT GGC AAG GTT AAT GAT GCT ATA CAT    3276
Thr Gln Ala Phe Gly Lys Val Asn Asp Ala Ile His
                1085                1090

CAA ACA TCA AAA GGT CTT GCA ACT GTT GCT AAA GCA    3312
Gln Thr Ser Lys Gly Leu Ala Thr Val Ala Lys Ala
        1095                1100

TTG GCA AAA GTG CAA GAT GTT GTC AAC ACA CAA GGG    3348
Leu Ala Lys Val Gln Asp Val Val Asn Thr Gln Gly
1105                1110                1115

CAA GCT TTA AGC CAC CTA ACA GTA CAA TTG CAA AAT    3384
Gln Ala Leu Ser His Leu Thr Val Gln Leu Gln Asn
            1120                1125

AAT TTT CAA GCC ATT AGT AGC TCT ATT AGT GAT ATT    3420
Asn Phe Gln Ala Ile Ser Ser Ser Ile Ser Asp Ile
    1130                1135                1140

TAT AAC AGG CTT GAC GAA CTG AGT GCT GAT GCA CAA    3456
Tyr Asn Arg Leu Asp Glu Leu Ser Ala Asp Ala Gln
                1145                1150

GTT GAT AGG CTG ATT ACA GGA AGA CTT ACA GCA CTT    3492
Val Asp Arg Leu Ile Thr Gly Arg Leu Thr Ala Leu
        1155                1160

AAT GCA TTT GTG TCT CAG ACT CTA ACC AGA CAA GCG    3528
Asn Ala Phe Val Ser Gln Thr Leu Thr Arg Gln Ala
1165                1170                1175

GAG GTT AGG GCT AGT AGA CAA CTT GCC AAG GAC AAG    3564
Glu Val Arg Ala Ser Arg Gln Leu Ala Lys Asp Lys
            1180                1185

GTT AAT GAA TGT GTT AGA TCC CAA TCT CAG AGA TTT    3600
Val Asn Glu Cys Val Arg Ser Gln Ser Gln Arg Phe
    1190                1195                1200

GGA TTC TGT GGT AAT GGT ACA CAC TTG TTT TCA CTT    3636
Gly Phe Cys Gly Asn Gly Thr His Leu Phe Ser Leu
                1205                1210

GCA AAT GCA GCA CCA AAT GGC ATG ATT TTC TTT CAT    3672
Ala Asn Ala Ala Pro Asn Gly Met Ile Phe Phe His
        1215                1220
```

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FIGURE 4 (cont'd)

```
ACA GTG CTA TTA CCA ACG GCT TAT GAA ACT GTA ACA     3708
Thr Val Leu Leu Pro Thr Ala Tyr Glu Thr Val Thr
1225                1230                1235

GCT TGG CCA GGT ATT TGT GCT TCA GAT GGC GAT CGC     3744
Ala Trp Pro Gly Ile Cys Ala Ser Asp Gly Asp Arg
            1240                1245

ACT TTT GGA CTT GTC GTT AAA GAT GTA CAG TTG ACG     3780
Thr Phe Gly Leu Val Val Lys Asp Val Gln Leu Thr
    1250                1255                1260

TTG TTT CGT AAC CTA GAT GAC AAG TTC TAT TTG ACT     3816
Leu Phe Arg Asn Leu Asp Asp Lys Phe Tyr Leu Thr
                1265                1270

CCC AGA ACT ATG TAT CAG CCT AGA GCT GCA ACT AGT     3852
Pro Arg Thr Met Tyr Gln Pro Arg Ala Ala Thr Ser
        1275                1280

TCT GAT TTT GTT CAA ATT GAG GGG TGC GAT GTG TTG     3888
Ser Asp Phe Val Gln Ile Glu Gly Cys Asp Val Leu
1285                1290                1295

TTT GTC AAT GCA ACT GTA ATT GAC TTG CCT AGT ATT     3924
Phe Val Asn Ala Thr Val Ile Asp Leu Pro Ser Ile
            1300                1305

ATA CCT GAC TAT ATT GAC ATC AAT CAG ACT GTT CAA     3960
Ile Pro Asp Tyr Ile Asp Ile Asn Gln Thr Val Gln
    1310                1315                1320

GAT ATA TTA GAA AAT TAC AGA CCA AAC TGG ACT GTA     3996
Asp Ile Leu Glu Asn Tyr Arg Pro Asn Trp Thr Val
                1325                1330

CCT GAA TTG ACA CTT GAT ATT TTT AAC GCA ACC TAT     4032
Pro Glu Leu Thr Leu Asp Ile Phe Asn Ala Thr Tyr
        1335                1340

TTA AAT CTG ACT GGT GAA ATT GAT GAC TTA GAA TTT     4068
Leu Asn Leu Thr Gly Glu Ile Asp Asp Leu Glu Phe
1345                1350                1355

AGG TCA GAA AAG CTA CAC AAT ACC ACT GTA GAA CTT     4104
Arg Ser Glu Lys Leu His Asn Thr Thr Val Glu Leu
            1360                1365

GCC ATT CTC ATT GAC AAC ATT AAC AAC ACA TTA GTC     4140
Ala Ile Leu Ile Asp Asn Ile Asn Asn Thr Leu Val
    1370                1375                1380
```

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FIGURE 4 (cont'd)

```
AAT CTT GAA TGG CTC AAT AGA ATT GAA ACT TAT GTA     4176
Asn Leu Glu Trp Leu Asn Arg Ile Glu Thr Tyr Val
                1385                1390

AAA TGG CCT TGG TAT GTG TGG CTA CTA ATA GGC TTA     4212
Lys Trp Pro Trp Tyr Val Trp Leu Leu Ile Gly Leu
        1395                1400

GTA GTA ATA TTT TGC ATA CCA TTA TTG CTA TTT TGC     4248
Val Val Ile Phe Cys Ile Pro Leu Leu Leu Phe Cys
1405                1410                1415

TGT TGT AGT ACA GGT TGT TGT GGA TGC ATA GGT TGC     4284
Cys Cys Ser Thr Gly Cys Cys Gly Cys Ile Gly Cys
            1420                1425

TTA GGA AGT TGT TGT CAC TCT ATG TGT AGT AGA AGA     4320
Leu Gly Ser Cys Cys His Ser Met Cys Ser Arg Arg
    1430                1435                1440

CAA TTT GAA AAT TAT GAA CCA ATT GAA AAA GTG CAT     4356
Gln Phe Glu Asn Tyr Glu Pro Ile Glu Lys Val His
                1445                1450

GTC CAC TAA                                         4365
Val His
```

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FIGURE 5

UCD-2, nucleotides 1 - 377 [SEQ ID NO:]
UCD-2, amino acids 1 - 125 [SEQ ID NO:]

```
AAT GCT CGT GGT AAA CCA TTA TTA TTT CAT GTG CAT     36
Asn Ala Arg Gly Lys Pro Leu Leu Phe His Val His
 1               5                  10

GGT GAG CCT GTT AGT GTT ATT ATA TAT ATA TCG GCT     72
Gly Glu Pro Val Ser Val Ile Ile Tyr Ile Ser Ala
        15                  20

TAT AGG GAT GAT GTG CAA CAA AGG CCC CTT TTA AAA    108
Tyr Arg Asp Asp Val Gln Gln Arg Pro Leu Leu Lys
25                  30                  35

CAT GGG TTA GTG TGC ATA ACT AAA AAT CGC CAT ATT    144
His Gly Leu Val Cys Ile Thr Lys Asn Arg His Ile
            40                  45

AAC TAT GAA CAA TTC ACC TCC AAC CAG TGG AAT TCC    180
Asn Tyr Glu Gln Phe Thr Ser Asn Gln Trp Asn Ser
    50                  55                  60

ACA TGT ACG GGT GCT GAC AGA AAA ATT CCT TTC TCT    216
Thr Cys Thr Gly Ala Asp Arg Lys Ile Pro Phe Ser
                65                  70

GTC ATA CCC ACG GAC AAT GGA ACA AAA ATC TAT GGT    252
Val Ile Pro Thr Asp Asn Gly Thr Lys Ile Tyr Gly
        75                  80

CTT GAG TGG AAT GAT GAC TTT GTT ACA GCT TAT ATT    288
Leu Glu Trp Asn Asp Asp Phe Val Thr Ala Tyr Ile
85                  90                  95

AGT GGT CGT TCT TAT CAC TTG AAC ATC AAT ACT AAT    324
Ser Gly Arg Ser Tyr His Leu Asn Ile Asn Thr Asn
            100                 105

TGG TTT AAC AAT GTC ACA CTT TTG TAT TCA CGC TCA    360
Trp Phe Asn Asn Val Thr Leu Leu Tyr Ser Arg Ser
    110                 115                 120

AGC ACT GCT ACC TGG GA                             377
Ser Thr Ala Thr Trp
                125
```

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FIGURE 6

Consensus Sequence
Nucleotides 1 - 2246 [SEQ ID NO:]
Amino acids 1 - 748 [SEQ ID NO:]

```
ATG ATT GTG CTC GTA ACT TGC CTC TTG TTG TTA TGT TCA    39
Met Ile Val Leu Val Thr Cys Leu Leu Leu Leu Cys Ser
 1               5                  10

TAC CAC ACA GTT TTG AGT ACA ACA AAT AAT GAA TGC ATA    78
Tyr His Thr Val Leu Ser Thr Thr Asn Asn Glu Cys Ile
     15                 20                  25

CAA GTT AAC GTA ACA CAA TTG GCT GGC AAT GAA AAC CTT   117
Gln Val Asn Val Thr Gln Leu Ala Gly Asn Glu Asn Leu
            30                  35

ATC AGA GAT TTT CTG TTT AGT AAC TTT AAA GAA GAA GGA   156
Ile Arg Asp Phe Leu Phe Ser Asn Phe Lys Glu Glu Gly
 40                  45                  50

AGT GTA GTT GTT GGT GGT TAT TAC CCT ACA GAG GTG TGG   195
Ser Val Val Val Gly Gly Tyr Tyr Pro Thr Glu Val Trp
         55                  60                  65

TAC AAC TGC TCT AGA ACA GCT CGA ACT ACT GCC TTT CAG   234
Tyr Asn Cys Ser Arg Thr Ala Arg Thr Thr Ala Phe Gln
                 70                  75

TAT TTT AAT AAT ATA CAT GCC TTT TAT TTT GTT ATG GAA   273
Tyr Phe Asn Asn Ile His Ala Phe Tyr Phe Val Met Glu
     80                  85                  90

GCC ATG GAA AAT AGC ACT GGT AAT GCA CGT GGT AAA CCA   312
Ala Met Glu Asn Ser Thr Gly Asn Ala Arg Gly Lys Pro
             95                 100

TTA TTA TTT CAT GTG CAT GGT GAG CCT GTT AGT GTT ATT   351
Leu Leu Phe His Val His Gly Glu Pro Val Ser Val Ile
105                 110                 115

ATA TAT ATA TCG GCT TAT AGG GAT GAT GTG CAA CAA AGG   390
Ile Tyr Ile Ser Ala Tyr Arg Asp Asp Val Gln Gln Arg
        120                 125                 130

CCC CTT TTA AAA CAT GGG TTA GTG TGC ATA ACT AAA AAT   429
Pro Leu Leu Lys His Gly Leu Val Cys Ile Thr Lys Asn
                135                 140

CGC CAT ATT AAC TAT GAA CAA TTC ACC TCC AAC CAG TGG   468
Arg His Ile Asn Tyr Glu Gln Phe Thr Ser Asn Gln Trp
    145                 150                 155
```

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FIGURE 6 (cont'd)

```
AAT TCC ACA TGT ACG GGT GCT GAC AGA AAA ATT CCT TTC   507
Asn Ser Thr Cys Thr Gly Ala Asp Arg Lys Ile Pro Phe
            160                 165

TCT GTC ATA CCC ACG GAC AAT GGA ACA AAA ATC TAT GGT   546
Ser Val Ile Pro Thr Asp Asn Gly Thr Lys Ile Tyr Gly
170                 175                 180

CTT GAG TGG AAT GAT GAC TTT GTT ACA GCT TAT ATT AGT   585
Leu Glu Trp Asn Asp Asp Phe Val Thr Ala Tyr Ile Ser
        185                 190                 195

GGT CGT TCT TAT CAC TTG AAC ATC AAT ACT AAT TGG TTT   624
Gly Arg Ser Tyr His Leu Asn Ile Asn Thr Asn Trp Phe
                200                 205

AAC AAT GTC ACA CTT TTG TAT TCA CGC TCA AGC ACT GCT   663
Asn Asn Val Thr Leu Leu Tyr Ser Arg Ser Ser Thr Ala
    210                 215                 220

ACC TGG GAA TAC AGT GCT GCA TAT GCT TAC CAA GGT GTT   702
Thr Trp Glu Tyr Ser Ala Ala Tyr Ala Tyr Gln Gly Val
            225                 230

TCT AAC TTC ACT TAT TAC AAG TTA AAT AAC ACC AAT GGT   741
Ser Asn Phe Thr Tyr Tyr Lys Leu Asn Asn Thr Asn Gly
235                 240                 245

CTA AAA ACC TAT GAA TTA TGT GAA GAT TAT GAA CAT TGC   780
Leu Lys Thr Tyr Glu Leu Cys Glu Asp Tyr Glu His Cys
        250                 255                 260

ACT GGC TAT GCT ACC AAT GTA TTT GCT CCG ACA TCA GGT   819
Thr Gly Tyr Ala Thr Asn Val Phe Ala Pro Thr Ser Gly
                265                 270

GGT TAC ATA CCT GAT GGA TTT AGT TTT AAY AAT TGG TTC   858
Gly Tyr Ile Pro Asp Gly Phe Ser Phe Asn Asn Trp Phe
    275                 280                 285

TTG CTT ACA AAT AGT TCC ACT TTT GTT AGT GGC AGG TTT   897
Leu Leu Thr Asn Ser Ser Thr Phe Val Ser Gly Arg Phe
            290                 295

GTA ACA AAT CAA CCA TTA TTG ATT AAT TGC TTG TGG CCA   936
Val Thr Asn Gln Pro Leu Leu Ile Asn Cys Leu Trp Pro
300                 305                 310

GTG CCC AGT TTT GGT GTA GCA GCA CAA GAA TTT TGT TTT   957
Val Pro Ser Phe Gly Val Ala Ala Gln Glu Phe Cys Phe
        315                 320                 325
```

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FIGURE 6 (cont'd)

```
GAA GGT GCA CAG TTT AGC CAA TGT AAT GGT GTG TCT TTA   1014
Glu Gly Ala Gln Phe Ser Gln Cys Asn Gly Val Ser Leu
                330                 335

AAT AAC ACA GTG GAT GTT ATT AGA TTC AAC CTT AAT TTC   1053
Asn Asn Thr Val Asp Val Ile Arg Phe Asn Leu Asn Phe
    340                 345                 350

ACT GCA GAT GTA CAA TCT GGT ATG GGT GCT ACA GTA TTT   1092
Thr Ala Asp Val Gln Ser Gly Met Gly Ala Thr Val Phe
            355                 360

TCA CTG AAT ACA ACA GGT GGT GTC ATT CTT GAA ATT TCA   1131
Ser Leu Asn Thr Thr Gly Gly Val Ile Leu Glu Ile Ser
365                 370                 375

TGT TAT AGT GAC ACA GTG AGT GAG TCT AGT TCT TAC AGT   1170
Cys Tyr Ser Asp Thr Val Ser Glu Ser Ser Ser Tyr Ser
        380                 385                 390

TAT GGT GAA ATC CCG TTC GGC ATA ACT GAC GGA CCA CGA   1209
Tyr Gly Glu Ile Pro Phe Gly Ile Thr Asp Gly Pro Arg
                395                 400

TAC TGT TAT GTA CTT TAC AAT GGC ACA GCT CTT AAA TAT   1248
Tyr Cys Tyr Val Leu Tyr Asn Gly Thr Ala Leu Lys Tyr
    405                 410                 415

TTA GGA ACA TTA CCA CCC AGT GTA AAG GAA ATT GCT ATT   1287
Leu Gly Thr Leu Pro Pro Ser Val Lys Glu Ile Ala Ile
            420                 425

AGT AAG TGG GGC CAT TTT TAT ATT AAT GGT TAC AAT TTC   1326
Ser Lys Trp Gly His Phe Tyr Ile Asn Gly Tyr Asn Phe
430                 435                 440

TTT AGC ACA TTT CCT ATT GRT TGT ATA TCT TTT AAT TTA   1365
Phe Ser Thr Phe Pro Ile Xaa Cys Ile Ser Phe Asn Leu
        445                 450                 455

ACC ACT GGT GTT AGT GGA GCT TTT TGG ACA ATT GCT TAC   1404
Thr Thr Gly Val Ser Gly Ala Phe Trp Thr Ile Ala Tyr
                460                 465

ACA TCG TAT ACT GAA GCA TTA GTA CAA GTT GAA AAC ACA   1443
Thr Ser Tyr Thr Glu Ala Leu Val Gln Val Glu Asn Thr
    470                 475                 480

GCT ATT AAA AAT GTG ACG TAT TGT AAC AGT CAC ATT AAT   1482
Ala Ile Lys Asn Val Thr Tyr Cys Asn Ser His Ile Asn
            485                 490
```

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FIGURE 6 (cont'd)

```
AAC ATT AAA TGT TCT CAA CTT ACT GCT AAT TTG AAT AAT  1521
Asn Ile Lys Cys Ser Gln Leu Thr Ala Asn Leu Asn Asn
495                 500                 505

GGA TTT TAT CCT GTT GCT TCA AGT GAA GTA GGT TTC GTT  1560
Gly Phe Tyr Pro Val Ala Ser Ser Glu Val Gly Phe Val
        510                 515                 520

AAT AAG AGT GTT GTG TTA TTA CCT AGC TTT TTC ACA TAC  1599
Asn Lys Ser Val Val Leu Leu Pro Ser Phe Phe Thr Tyr
                525                 530

ACC GCT GTC AAT ATA ACC ATT GAT CTT GGT ATG AAG CTT  1638
Thr Ala Val Asn Ile Thr Ile Asp Leu Gly Met Lys Leu
    535                 540                 545

AGT GGT TAT GGT CAA CCC ATA GCC TCG ACA CTA AGT AAC  1677
Ser Gly Tyr Gly Gln Pro Ile Ala Ser Thr Leu Ser Asn
            550                 555

ATC ACA CTA CCA ATG CAG GAT AAC AAT ACT GAT GTG TAC  1716
Ile Thr Leu Pro Met Gln Asp Asn Asn Thr Asp Val Tyr
560                 565                 570

TGT ATT CGT TCT AAC CAA TTC TCA GTT TAT GTT CAT TCC  1755
Cys Ile Arg Ser Asn Gln Phe Ser Val Tyr Val His Ser
        575                 580                 585

ACT TGC AAA AGT TCT TTA TGG GAC AAT ATT TTT AAT CAA  1794
Thr Cys Lys Ser Ser Leu Trp Asp Asn Ile Phe Asn Gln
                590                 595

GAC TGC ACG GAT GTT TTA GAG GCT ACA GCT GTT ATA AAA  1833
Asp Cys Thr Asp Val Leu Glu Ala Thr Ala Val Ile Lys
    600                 605                 610

ACT GGT ACT TGT CCT TTC TCA TTT GAT AAA TTG AAC AAT  1872
Thr Gly Thr Cys Pro Phe Ser Phe Asp Lys Leu Asn Asn
            615                 620

TAC TTG ACT TTT AAC AAG TTC TGT TTG TCG TTG AGT CCT  1911
Tyr Leu Thr Phe Asn Lys Phe Cys Leu Ser Leu Ser Pro
625                 630                 635

GTT GGT GCT AAT TGC AAG TTT GAT GTT GCT GCA CGT ACA  1950
Val Gly Ala Asn Cys Lys Phe Asp Val Ala Ala Arg Thr
        640                 645                 650

AGA ACC AAT GAG CAG GTT GTT AGA AGT CTA TAT GTA ATA  1989
Arg Thr Asn Glu Gln Val Val Arg Ser Leu Tyr Val Ile
                655                 660
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FIGURE 6 (cont'd)

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TAT GAA GAA GGA GAC AAC ATA GTG GGT GTA CCG TCT GAT   2028
Tyr Glu Glu Gly Asp Asn Ile Val Gly Val Pro Ser Asp
    665                 670                 675

RAT AGC GGT CTG CAC GAT TTG TCT GTG CTA CAC CTA GAC   2067
Xaa Ser Gly Leu His Asp Leu Ser Val Leu His Leu Asp
            680                 685

TCC TGT ACA GAT TAC AAT ATA TAT GGT AGA ACT GGT GTT   2106
Ser Cys Thr Asp Tyr Asn Ile Tyr Gly Arg Thr Gly Val
690                 695                 700

GGT ATT ATT AGA CGA ACT AAC AGT ACG CTA CTT AGT GGC   2145
Gly Ile Ile Arg Arg Thr Asn Ser Thr Leu Leu Ser Gly
        705                 710                 715

TTA TAT TAC ACA TCA CTA TCA GGT GAT TTG TTA GGC TTT   2184
Leu Tyr Tyr Thr Ser Leu Ser Gly Asp Leu Leu Gly Phe
                720                 725

AAA AAT GTT AGT GAT GGT GTC ATT TAT TCT GTG ACG CCA   2223
Lys Asn Val Ser Asp Gly Val Ile Tyr Ser Val Thr Pro
    730                 735                 740

TGT GAT GTA AGC GCA CAA GCG GC                        2246
Cys Asp Val Ser Ala Gln Ala
            745
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FIGURE 7

CCV S gene sequence, nucleotides [SEQ ID NO:]
CCV S gene sequence, amino acids [SEQ ID NO:]

```
AGG CCT CTT TTA AAA CAT GGT TTG TTG TGT ATA ACT AAA AAT AAA ATC        48
Arg Pro Leu Leu Lys His Gly Leu Leu Cys Ile Thr Lys Asn Lys Ile
 1               5                  10                  15

ATT GAC TAT AAC ACG TTT ACC AGC GCA CAG TGG AGT GCC ATA TGT TTG        96
Ile Asp Tyr Asn Thr Phe Thr Ser Ala Gln Trp Ser Ala Ile Cys Leu
            20                  25                  30

GGT GAT GAC AGA AAA ATA CCA TTC TCT GTC ATA CCC ACA GGT AAT GGT       144
Gly Asp Asp Arg Lys Ile Pro Phe Ser Val Ile Pro Thr Gly Asn Gly
        35                  40                  45

ACA AAA ATA TTT GGT CTT GAG TGG AAT GAT GAC TAT GTT ACA GCC TAT       192
Thr Lys Ile Phe Gly Leu Glu Trp Asn Asp Asp Tyr Val Thr Ala Tyr
    50                  55                  60

ATT AGT GAT CGT TCT CAC CAT TTG AAC ATC AAT AAT AAT TGG TTT AAC       240
Ile Ser Asp Arg Ser His His Leu Asn Ile Asn Asn Asn Trp Phe Asn
65                  70                  75                  80

AAT GTG ACA ATC CTA TAC TCT CGA TCA AGC ACT GCT ACG TGG CAG AAG       288
Asn Val Thr Ile Leu Tyr Ser Arg Ser Ser Thr Ala Thr Trp Gln Lys
                85                  90                  95

AGT GCT GCA TAT GTT TAT CAA GGT GTT TCA AAT TTT ACT TAT TAC AAG       336
Ser Ala Ala Tyr Val Tyr Gln Gly Val Ser Asn Phe Thr Tyr Tyr Lys
            100                 105                 110

TTA AAT AAC ACC AAT GGC TTG AAA AGC TAT GAA TTG TGT GAA GAT TAT       384
Leu Asn Asn Thr Asn Gly Leu Lys Ser Tyr Glu Leu Cys Glu Asp Tyr
        115                 120                 125

GAA TGC TGC ACT GGC TAT GCT ACC AAC GTA TTT GCC CCG ACA GTG GGC       432
Glu Cys Cys Thr Gly Tyr Ala Thr Asn Val Phe Ala Pro Thr Val Gly
    130                 135                 140

GGT TAT ATA CCT GAT GGC TTC AGT TTT AAC AAT TGG TTT ATG CTT ACA       480
Gly Tyr Ile Pro Asp Gly Phe Ser Phe Asn Asn Trp Phe Met Leu Thr
145                 150                 155                 160

AAC AGT TCC ACG TTT GTT AGT GGC AGA TTT GTA ACA AAT CAA CCA TTA       528
Asn Ser Ser Thr Phe Val Ser Gly Arg Phe Val Thr Asn Gln Pro Leu
                165                 170                 175

TTG GTT AAT TGT TTG TGG CCA GTG CCC AGT CTT GGT GTC GCA GCA CAA       576
Leu Val Asn Cys Leu Trp Pro Val Pro Ser Leu Gly Val Ala Ala Gln
            180                 185                 190

GAA TTT TGT TTT GAA GGT GCG CAG TTT AGC CAA TGT AAT GGT GTG TCT       624
Glu Phe Cys Phe Glu Gly Ala Gln Phe Ser Gln Cys Asn Gly Val Ser
        195                 200                 205

TTA AAC AAT ACA GTG GAT GTC ATT AGA TTC AAC CTT AAT TTT ACC ACA       672
Leu Asn Asn Thr Val Asp Val Ile Arg Phe Asn Leu Asn Phe Thr Thr
    210                 215                 220

GAT GTA CAA TCT GGT ATG GGT GCT ACA GTA TTT TCA CTG AAT ACA ACA       720
Asp Val Gln Ser Gly Met Gly Ala Thr Val Phe Ser Leu Asn Thr Thr
225                 230                 235                 240
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FIGURE 7 (cont'd)

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GGT GGT GTC ATT CTT GAG ATT TCT TGT TAT AAT GAT ACA GTG AGT GAG     768
Gly Gly Val Ile Leu Glu Ile Ser Cys Tyr Asn Asp Thr Val Ser Glu
                245                 250                 255

TCA AGT TTC TAC AGT TAT GGT GAA ATT TCA TTC GGC GTA ACT GAT GGA     816
Ser Ser Phe Tyr Ser Tyr Gly Glu Ile Ser Phe Gly Val Thr Asp Gly
            260                 265                 270

CCG CGT TAC TGT TAC GCA CTC TAT AAT GGC ACG GCT CTT AAG TAT TTA     864
Pro Arg Tyr Cys Tyr Ala Leu Tyr Asn Gly Thr Ala Leu Lys Tyr Leu
        275                 280                 285

GGA ACA TTA CCA CCT AGT GTC AAG GAA ATT GCT ATT AGT AAG TGG GGC     912
Gly Thr Leu Pro Pro Ser Val Lys Glu Ile Ala Ile Ser Lys Trp Gly
    290                 295                 300

CAT TTT TAT ATT AAT GGT TAC AAT TTC TTT AGC ACT TTT CCT ATT GAT     960
His Phe Tyr Ile Asn Gly Tyr Asn Phe Phe Ser Thr Phe Pro Ile Asp
305                 310                 315                 320

TGT ATA TCT TTT AAT TTA ACC ACT GGT GAT AGT GGA GCA TTT TGG ACA    1008
Cys Ile Ser Phe Asn Leu Thr Thr Gly Asp Ser Gly Ala Phe Trp Thr
                325                 330                 335

ATT GCT TAC ACA TCG TAC ACT GAC GCA TTA GTA CAA GTT GAA AAC ACA    1056
Ile Ala Tyr Thr Ser Tyr Thr Asp Ala Leu Val Gln Val Glu Asn Thr
            340                 345                 350

GCT ATT AAA AAG GTG ACG TAT TGT AAC AGT CAC ATT AAT AAC ATT AAA    1104
Ala Ile Lys Lys Val Thr Tyr Cys Asn Ser His Ile Asn Asn Ile Lys
        355                 360                 365

TGT TCT CAA CTT ACT GCT AAT TTG CAA AAT GGA TTT TAT CCT GTT GCT    1152
Cys Ser Gln Leu Thr Ala Asn Leu Gln Asn Gly Phe Tyr Pro Val Ala
    370                 375                 380

TCA AGT GAA GTT GGT CTT GTC AAT AAG AGT GTT GTG TTA CTA CCT AGT    1200
Ser Ser Glu Val Gly Leu Val Asn Lys Ser Val Val Leu Leu Pro Ser
385                 390                 395                 400

TTC TAT TCA CAT ACC AGT GTT AAT ATA ACT ATT GAT CTT GGT ATG AAG    1248
Phe Tyr Ser His Thr Ser Val Asn Ile Thr Ile Asp Leu Gly Met Lys
                405                 410                 415

CGT AGT GGT TAT GGT CAA CCC ATA GCC TCA ACA TTA AGT AAC ATC ACA    1296
Arg Ser Gly Tyr Gly Gln Pro Ile Ala Ser Thr Leu Ser Asn Ile Thr
            420                 425                 430

CTA CCA ATG CAG GAT AAT AAC ACC GAT GTG TAC TGC ATT CGT TCT AAC    1344
Leu Pro Met Gln Asp Asn Asn Thr Asp Val Tyr Cys Ile Arg Ser Asn
        435                 440                 445

CAA TTT TCA GTT TAC GTT CAT TCC ACT TGT AAA AGT TCT TTA TGG GAC    1392
Gln Phe Ser Val Tyr Val His Ser Thr Cys Lys Ser Ser Leu Trp Asp
    450                 455                 460

GAT GTG TTT AAT TCC GAC TGC ACA GAT GTT TTA TAT GCT ACA GCT GTT    1440
Asp Val Phe Asn Ser Asp Cys Thr Asp Val Leu Tyr Ala Thr Ala Val
465                 470                 475                 480

ATA AAA ACT GGT ACT TGT CCT TTC TCG TTT GAT AAA TTG AAC AAT TAC    1488
Ile Lys Thr Gly Thr Cys Pro Phe Ser Phe Asp Lys Leu Asn Asn Tyr
                485                 490                 495
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FIGURE 7 (cont'd)

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TTA ACT TTT AAC AAG TTC TGT TTG TCA TTG AAT CCT GTT GGT GCC AAC      1536
Leu Thr Phe Asn Lys Phe Cys Leu Ser Leu Asn Pro Val Gly Ala Asn
            500                 505                 510

TGC AAG TTT GAT GTT GCC GCT CGT ACA AGA ACC AAT GAG CAG GTT GTT      1584
Cys Lys Phe Asp Val Ala Ala Arg Thr Arg Thr Asn Glu Gln Val Val
        515                 520                 525

AGA AGT TTA TAT GTA ATA TAT GAA GAA GGA GAC AAC ATA GTG GGT GTG      1632
Arg Ser Leu Tyr Val Ile Tyr Glu Glu Gly Asp Asn Ile Val Gly Val
    530                 535                 540

CCG TCT GAC AAT AGT GGT CTT CAC GAC TTG TCA GTG CTA CAC TTA GAC      1680
Pro Ser Asp Asn Ser Gly Leu His Asp Leu Ser Val Leu His Leu Asp
545                 550                 555                 560

TCC TGT ACA GAT TAT AAT ATA TAT GGT AGA ACT GGT GTT GGT ATT ATT      1728
Ser Cys Thr Asp Tyr Asn Ile Tyr Gly Arg Thr Gly Val Gly Ile Ile
                565                 570                 575

AGA CAA ACT AAC AGT ACG CTA CTT AGT GGC TTA TAT TAC ACA TCA CTA      1776
Arg Gln Thr Asn Ser Thr Leu Leu Ser Gly Leu Tyr Tyr Thr Ser Leu
            580                 585                 590

TCA GGT GAC TTG TTA GGG TTT AAA AAT GTT AGT GAT GGT GTC ATC TAT      1824
Ser Gly Asp Leu Leu Gly Phe Lys Asn Val Ser Asp Gly Val Ile Tyr
        595                 600                 605

TCT GTC ACG CCA TGT GAT GTA AGC GCA CAA GCT GCT GTT ATT GAT GGC      1872
Ser Val Thr Pro Cys Asp Val Ser Ala Gln Ala Ala Val Ile Asp Gly
    610                 615                 620

GCC ATA GTT GGA GCT ATG ACT TCC ATT AAT AGT GAA ATG TTA GGT CTA      1920
Ala Ile Val Gly Ala Met Thr Ser Ile Asn Ser Glu Met Leu Gly Leu
625                 630                 635                 640

ACA CAT TGG ACA ACA ACA CCT AAT TTT TAT TAT TAT TCT ATA TAT AAT      1968
Thr His Trp Thr Thr Thr Pro Asn Phe Tyr Tyr Tyr Ser Ile Tyr Asn
                645                 650                 655

TAT ACC AAT GAA AGG ACT CGT GGC ACA GCA ATT GAT AGT AAC GAT GTT      2016
Tyr Thr Asn Glu Arg Thr Arg Gly Thr Ala Ile Asp Ser Asn Asp Val
            660                 665                 670

GAT TGT GAA CCT ATC ATA ACC TAT TCT AAT ATA GGT GTT TGT AAA AAT      2064
Asp Cys Glu Pro Ile Ile Thr Tyr Ser Asn Ile Gly Val Cys Lys Asn
        675                 680                 685

GGA GCT TTG GTT TTT ATT AAC GTC ACA CAT TCT GAT GGA GAC GTT CAA      2112
Gly Ala Leu Val Phe Ile Asn Val Thr His Ser Asp Gly Asp Val Gln
    690                 695                 700

CCA ATT AGC ACC GGT AAT GTC ACG ATA CCT ACA AAT TTT ACC ATA TCT      2160
Pro Ile Ser Thr Gly Asn Val Thr Ile Pro Thr Asn Phe Thr Ile Ser
705                 710                 715                 720

GTG CAA GTT GAG TAC ATT CAG GTT TAC ACT ACA CCG GTG TCA ATA GAT      2208
Val Gln Val Glu Tyr Ile Gln Val Tyr Thr Thr Pro Val Ser Ile Asp
                725                 730                 735

TGT TCA AGG TAC GTT TGC AAT GGT AAC CCT AGA TGC AAT AAA TTG TTA      2256
Cys Ser Arg Tyr Val Cys Asn Gly Asn Pro Arg Cys Asn Lys Leu Leu
            740                 745                 750
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FIGURE 7 (cont'd)

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ACG CAA TAC GTT TCT GCA TGT CAA ACT ATT GAG CAA GCA CTT GCA ATG         2304
Thr Gln Tyr Val Ser Ala Cys Gln Thr Ile Glu Gln Ala Leu Ala Met
        755                 760                 765

GGT GCC AGA CTT GAA AAC ATG GAG ATT GAT TCC ATG TTG TTT GTT TCG         2352
Gly Ala Arg Leu Glu Asn Met Glu Ile Asp Ser Met Leu Phe Val Ser
    770                 775                 780

GAA AAT GCC CTT AAA TTG GCA TCT GTT GAA GCA TTC AAT AGT ACG GAA         2400
Glu Asn Ala Leu Lys Leu Ala Ser Val Glu Ala Phe Asn Ser Thr Glu
785                 790                 795                 800

ACT TTA GAT CCT ATT TAC AAA GAA TGG CCT AAC ATT GGT GGT TCT TGG         2448
Thr Leu Asp Pro Ile Tyr Lys Glu Trp Pro Asn Ile Gly Gly Ser Trp
                805                 810                 815

CTA GGA GGT TTA AAA GAC ATA TTG CCA TCT CAC AAC AGC AAA CGT AAG         2496
Leu Gly Gly Leu Lys Asp Ile Leu Pro Ser His Asn Ser Lys Arg Lys
            820                 825                 830

TAC CGG TCG GCT ATA GAA GAT TTG CTT TTT GAT AAG GTT GTA ACA TCT         2544
Tyr Arg Ser Ala Ile Glu Asp Leu Leu Phe Asp Lys Val Val Thr Ser
        835                 840                 845

GGC TTA GGT ACA GTT GAT GAA GAT TAT AAA CGT TGT ACA GGT GGT TAT         2592
Gly Leu Gly Thr Val Asp Glu Asp Tyr Lys Arg Cys Thr Gly Gly Tyr
    850                 855                 860

GAC ATA GCT GAC TTA GTG TGT GCA CAA TAT TAC AAT GGC ATC ATG GTG         2640
Asp Ile Ala Asp Leu Val Cys Ala Gln Tyr Tyr Asn Gly Ile Met Val
865                 870                 875                 880

CTA CCT GGT GTA GCT AAT GAT GAC AAG ATG GCT ATG TAC ACT GCA TCT         2688
Leu Pro Gly Val Ala Asn Asp Asp Lys Met Ala Met Tyr Thr Ala Ser
                885                 890                 895

CTT GCA GGT GGT ATA ACA TTA GGT GCA CTT GGT GGT GGC GCA GTG TCT         2736
Leu Ala Gly Gly Ile Thr Leu Gly Ala Leu Gly Gly Gly Ala Val Ser
            900                 905                 910

ATA CCT TTT GCA ATA GCA GTT CAA GCC AGA CTT AAT TAT GTT GCT CTA         2784
Ile Pro Phe Ala Ile Ala Val Gln Ala Arg Leu Asn Tyr Val Ala Leu
        915                 920                 925

CAA ACT GAT GTA TTG AGC AAG AAC CAG CAG ATC CTG GCT AAT GCT TTC         2832
Gln Thr Asp Val Leu Ser Lys Asn Gln Gln Ile Leu Ala Asn Ala Phe
    930                 935                 940

AAT CAA GCT ATT GGT AAC ATT ACA CAG GCA TTT GGT AAG GTT AAT GAT         2880
Asn Gln Ala Ile Gly Asn Ile Thr Gln Ala Phe Gly Lys Val Asn Asp
945                 950                 955                 960

GCT ATA CAT CAA ACG TCA CAA GGT CTT GCT ACT GTT GCT AAA GCA TTG         2928
Ala Ile His Gln Thr Ser Gln Gly Leu Ala Thr Val Ala Lys Ala Leu
                965                 970                 975

GCA AAA GTG CAA GAT GTT GTT AAC ACA CAA GGG CAA GCT TTA AGC CAC         2976
Ala Lys Val Gln Asp Val Val Asn Thr Gln Gly Gln Ala Leu Ser His
            980                 985                 990

CTA ACA GTA CAA TTG CAA AAT AAT TTC CAA GCC ATT AGT AGT TCC ATT         3024
Leu Thr Val Gln Leu Gln Asn Asn Phe Gln Ala Ile Ser Ser Ser Ile
        995                 1000                1005
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FIGURE 7 (cont'd)

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AGT GAC ATT TAT AAC AGG CTT GAT GAA TTG AGT GCT GAT GCA CAA GTT      3072
Ser Asp Ile Tyr Asn Arg Leu Asp Glu Leu Ser Ala Asp Ala Gln Val
    1010                1015                1020

GAC AGG CTG ATT ACA GGA AGA CTT ACA GCA CTT AAT GCA TTT GTG TCT      3120
Asp Arg Leu Ile Thr Gly Arg Leu Thr Ala Leu Asn Ala Phe Val Ser
1025                1030                1035                1040

CAG ACT TTA ACC AGA CAA GCA GAG GTT AGG GCT AGC AGA CAG CTT GCT      3168
Gln Thr Leu Thr Arg Gln Ala Glu Val Arg Ala Ser Arg Gln Leu Ala
                1045                1050                1055

AAA GAC AAG GTA AAT GAA TGC GTT AGG TCT CAA TCT CAG AGA TTT GGA      3216
Lys Asp Lys Val Asn Glu Cys Val Arg Ser Gln Ser Gln Arg Phe Gly
            1060                1065                1070

TTC TGT GGT AAT GGT ACA CAT TTA TTT TCA CTT GCA AAT GCA GCA CCA      3264
Phe Cys Gly Asn Gly Thr His Leu Phe Ser Leu Ala Asn Ala Ala Pro
        1075                1080                1085

AAT GGC ATG ATC TTC TTT CAC ACA GTG CTA TTA CCA ACA GCT TAT GAA      3312
Asn Gly Met Ile Phe Phe His Thr Val Leu Leu Pro Thr Ala Tyr Glu
    1090                1095                1100

ACC GTG ACG GCC TGG TCA GGT ATT TGT GCA TCA GAT GGC GAT CGT ACT      3360
Thr Val Thr Ala Trp Ser Gly Ile Cys Ala Ser Asp Gly Asp Arg Thr
1105                1110                1115                1120

TTT GGA CTT GTT GTT AAG GAT GTC CAG TTG ACG CTG TTT CGC AAT CTA      3408
Phe Gly Leu Val Val Lys Asp Val Gln Leu Thr Leu Phe Arg Asn Leu
                1125                1130                1135

GAT GAC AAA TTC TAT TTG ACT CCC AGA ACT ATG TAT CAG CCT AGA GTT      3456
Asp Asp Lys Phe Tyr Leu Thr Pro Arg Thr Met Tyr Gln Pro Arg Val
            1140                1145                1150

GCA ACT AGT TCT GAT TTT GTT CAA ATT GAA GGA TGT GAT GTG TTG TTT      3504
Ala Thr Ser Ser Asp Phe Val Gln Ile Glu Gly Cys Asp Val Leu Phe
        1155                1160                1165

GTT AAT GCA ACT GTA ATT GAC TTG CCT AGT ATT ATA CCT GAC TAT ATT      3552
Val Asn Ala Thr Val Ile Asp Leu Pro Ser Ile Ile Pro Asp Tyr Ile
    1170                1175                1180

GAT ATT AAT CAA ACT GTT CAG GAC ATA TTA GAA AAT TTC AGA CCA AAT      3600
Asp Ile Asn Gln Thr Val Gln Asp Ile Leu Glu Asn Phe Arg Pro Asn
1185                1190                1195                1200

TGG ACT GTA CCT GAG TTG CCA CTT GAC ATT TTC AAT GCA ACC TAC TTA      3648
Trp Thr Val Pro Glu Leu Pro Leu Asp Ile Phe Asn Ala Thr Tyr Leu
                1205                1210                1215

AAC CTG ACT GGT GAA ATT AAT GAC TTA GAA TTT AGG TCA GAA AAG TTA      3696
Asn Leu Thr Gly Glu Ile Asn Asp Leu Glu Phe Arg Ser Glu Lys Leu
            1220                1225                1230

CAT AAC ACC ACA GTA GAA CTT GCT ATT CTC ATT GAT AAT ATT AAT AAC      3744
His Asn Thr Thr Val Glu Leu Ala Ile Leu Ile Asp Asn Ile Asn Asn
        1235                1240                1245

ACA TTA GTC AAT CTT GAA TGG CTC AAT AGA ATT GAA ACT TAT GTA AAA      3792
Thr Leu Val Asn Leu Glu Trp Leu Asn Arg Ile Glu Thr Tyr Val Lys
    1250                1255                1260
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(9)

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FIGURE 7 (cont'd)

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TGG CCT TGG TAT GTG TGG CTA CTA ATT GGA TTA GTA GTA ATA TTC TGC    3840
Trp Pro Trp Tyr Val Trp Leu Leu Ile Gly Leu Val Val Ile Phe Cys
1265                1270                1275                1280

ATA CCC ATA TTG CTA TTT TGT TGT TGT AGC ACT GGT TGT TGT GGA TGT    3888
Ile Pro Ile Leu Leu Phe Cys Cys Cys Ser Thr Gly Cys Cys Gly Cys
                1285                1290                1295

ATT GGG TGT TTA GGA AGC TGT TGT CAT TCC ATA TGT AGT AGA AGG CGA    3936
Ile Gly Cys Leu Gly Ser Cys Cys His Ser Ile Cys Ser Arg Arg Arg
            1300                1305                1310

TTT GAA AGT TAT GAA CCA ATT GAA AAA GTG CAT GTC CAC TAA            3978
Phe Glu Ser Tyr Glu Pro Ile Glu Lys Val His Val His
        1315                1320                1325
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